Digitized by the Internet Archive
in 2011 with funding from
Boston Library Consortium Member Libraries

http://www.archive.org/details/manualofamerican1921amer2

MANUAL

OF THE

American Railway Engineering Association

Definitions, Specifications
and Principles of Practice

FOR

RAILWAY ENGINEERING

EDITION OF 1921

Published by
AMERICAN RAILWAY ENGINEERING ASSOCIATION
431 South Dearborn Street
CHICAGO, ILLINOIS

C

TF
145
A545
1921

625
1921

Copyright, 1921, by
AMERICAN RAILWAY ENGINEERING ASSOCIATION
Chicago, Illinois

148649

G. Miss Margaret Allen 8 March 1951

Manual of the American Railway Engineering Association

Foreword

Definition.

"Manual"—A compendium containing the essentials of a subject; a handbook; a textbook.

Backing and Responsibility.

The "Manual" is issued by the American Railway Engineering Association (functioning also as the Construction and Maintenance Section, Engineering Division, American Railway Association). The contents of the "Manual" therefore have the endorsement of these two important railway organizations as exemplifying the best current practice for railway engineering and maintenance of way work.

The American Railway Engineering Association is an organization of beavers—of workers. The twenty-five committees working year in and year out, composed of engineers of high standing in practically every branch of engineering, keep their subjects up-to-date. They not only keep up-to-date, but are pioneers and leaders in various lines.

Field Covered.

The "Manual" is the concentrated knowledge of the railway world as adopted by its engineers, and applies to construction, maintenance, and many phases of operation. The vastness of the field covered is all the more impressive when it is considered that the "Manual" is the condensed form of the text, representing only conclusions, but based on the most elaborate investigations and reports.

The "Manual's" usefulness is not confined to the printed text and illustrations. References are given by footnotes to volume, year and page to the context of the reports of committees, the discussions of the subjects, and the final action by the Association. It is therefore not only a textbook, but in a large measure a key to the library of the publications of the Association.

Simplicity.

The "Manual" is a summary of what we really know; and, like all knowledge, is simple. Things we actually know are generally simple; one who thinks clearly will generally express himself clearly. The "Manual" is an illustration.

38728

The "Manual" contains the conclusions in concise form on matters which have been the subject of special study by the Standing or Special Committees, and which after due consideration and discussion, have been formally approved by the Association. The Association sits as a legislature once a year; the laws which it passes are the conclusions adopted.

Conclusion.

1. Read the "Manual." If not all of it, read parts of it as often as practicable. Watch what goes into it. Keep posted as to revisions. Keep it always at your elbow.

2. Recommend it to engineers in other lines, and to every builder, manufacturer, or supply man interested in the construction, maintenance or operation of railways.

3. Bring it to the attention of every official on every railway in America—Managers and Executives, as well as Section Foremen and Carpenters. Educate your employees.

4. Use it as a textbook in class-work for educating the student in railway engineering.

TABLE OF CONTENTS.

CLASSIFICATION OF TRACK.

PAGE
Classification of Railways.... 16

ROADWAY.

Definitions 17
General Contract Requirements 21
Width of Roadway at Subgrade.... 21
Slopes of Roadway Cross-Section.... 22
Specifications for the Formation of the Roadway.... 22
Mechanical Shovels; Locomotive Cranes and Dragline Excavators; Shovel Methods and Operations 35
Shrinkage and Subsidence 52
Allowance for in Estimating 52
Grade Reduction Work 53
Track Elevation Work 54
Waterways 54
Slides 56
Washouts 57
Surface and Sub-Surface Drainage 57
Tunnels 57
Tunnel Construction 58
Tunnel Ventilation 62
Specifications for Sodding with Bermuda Grass.... 62
Means for Prevention or Cure of Water Pockets in Roadbed.... 64
Drainage of Roadway Through Stations and Yards.... 66
Grade Separation 67
Slopes for High Rock Cuts of Forty Feet in Height or More.... 67
Drainage of Large Cuts.... 68

BALLAST.

Definitions of Terms 69
Choice of Ballast 70
Comparative Merit of Material for Ballast.... 70
Specifications for Stone Ballast Material.... 71
Specifications for Washed Gravel Ballast.... 75
Ballast Sections, with Particular Reference to Sub- and Top-Ballast 80
Instructions to Govern Ballasting on and Operated Line.... 83
Organization and Distribution of a Ballast Raising Force of 77 Men 87
Specifications for Ballast Tools.... 88
Use and Limitation of Mechanical Tools.... 93
Cleaning Foul Ballast 93
Reinforcement Under Ballast 94
Ballasting by Contract 94

TIES.

Page
Definitions of Terms 95
Specification for Cross-Ties 97
Specification for Switch-Ties 101
Use of Dating Nails 105
Specifications for Dating Nails 105
Tie Renewals in Continuous Stretches versus Single Tie Renewals 106
Records of Cross-Ties 106
Economic Comparison of Cross-Ties of Different Materials...... 107

RAIL.

Standard Rail Sections 109
Specifications for Carbon Steel Rails 115
Drilling of Rails 124
Specifications for Drop Testing Machine 125
Standard Locations of Borings for Chemical Analysis and Tensile Test Pieces 128
Specifications for High-Carbon Steel Joint Bars 128
Specifications for Quenched Carbon and Quenched Alloy Steel Track Bolts with Nuts 130
Standard Test for Rail Joints 133
Specifications for Medium Carbon Steel Track Bolts with Nuts.. 135
Specifications for Quenched Carbon and Quenched Alloy Steel Joint Bars 137
Rail Record Forms 140

TRACK.

Definitions of Terms 155
Maintenance of Line 157
Spirals 160
Table of Functions of the Ten-Chord Spiral 166
Maintenance of Surface 184
Maintenance of Gage 186
Width of Standard Flangeway 187
Gage on Curves 188
Speeds of Trains Through Curves and Turnouts 188
Temperature Expansion for Laying Rails 194
Standard Rail Joint 194
Design of Track Fastenings 194
Specifications for Relayer Rail for Various Uses 194
Specifications for Steel Cut Track Spikes 197
Specifications for Steel Screw Spikes 198
Design of Cut Track Spike 199
Design of Screw Spike 200
Testing Gage for Screw Spike 202

TRACK—Continued. PAGE

Tie-Plates—General Principles of Design 203
Specifications for Steel Tie-Plates 203
Specifications for Wrought-Iron Tie-Plates 208
Specifications for Malleable Iron Tie-Plates 210
Anti-Creepers—General Requirements 212
Plans for Turnouts, Frogs, Switches and Fixtures 213
(See Portfolio for Plans.)
Specifications for Switches, Frogs, Crossings and Guard Rails 214
Frog Designs 221
Specifications for Design and Dimensions of Manganese Steel Pointed Switches 233
Requisites for Switch Stands, Including Connecting Rods 233
Desirable Agencies for Obtaining a Better Class of Section Foremen 236
Table of Practical Turnout Leads 237
Table of Theoretical Turnout Leads 238

BUILDINGS.

Definitions of Terms 239
Ashpits 240
Engine House Design 243
Freight Houses—Principles of Design of Inbound and Outbound 247
Locomotive Coaling Stations 256
Oil Houses 257
Passenger Stations 258
Rest Houses for Employees 265
Roofings 273
Section Tool Houses 279

WOODEN BRIDGES AND TRESTLES.

Definitions of Terms 281
Specifications for Timber Piles 283
Railroad Heart Grade 283
Railroad Falsework Grade 284
Pile-Driving—Principles of Practice 284
Pile Record Form 287
Specifications for Workmanship for Pile and Frame Trestles of Untreated Material Built Under Contract 288
Use of Guard Rails and Guard Timbers 291
Use of Lag Screws in Trestle Construction 291
Specifications for Metal Details Used in Wooden Bridges and Trestles 293
Relative Economy of Repairs and Renewals of Wooden Bridges and Trestles 295

Wooden Bridges and Trestles—Continued. Page

Comparative Merits of Ballast Deck and Reinforced Concrete Trestles 295
Economy Curves for Structures of Various Ratios of Life Periods 301
Working Stresses Permissible for Structural Timbers.......... 302
Specifications and Classification and Grading Rules for Lumber and Timber to be Used in the Maintenance of Way Department 303
  Definitions of Terms 303
  Names for Varieties of Structural Timber.......... 303
  Classification of Terms.......... 304
  Definitions of Blemishes and Defects.......... 306
  Specifications—Defects of Manufacture, applicable to all Timber and Lumber 330
  Standard Sizes 330
  General Instructions on Grading Timber and Lumber.......... 335
  Structural Grades for Bridge and Trestle Timber.......... 336
    Southern Yellow Pine and Douglas Fir Specifications.......... 336
    Density Rule for Southern Yellow Pine.......... 336
    Density Rule for Douglas Fir.......... 337
  Commercial Timber and Lumber Grades.......... 341
  Specifications for Construction Oak.......... 351
  Specifications for Structural Oak Timbers.......... 352
  Classification and Grading Rules for Cypress Lumber and Shingles 354
  Classification and Grading Rules for Hemlock Lumber.......... 360
  Classification of the Uses of Lumber.......... 364

MASONRY.

Definitions of Terms 369
Specifications for Portland Cement.......... 375
Specifications for Natural Cement.......... 392
Masonry Specifications 394
Specifications for Stone Masonry.......... 394
Specifications for Concrete, Plain and Reinforced.......... 400
Specifications for Billet-Steel Concrete Reinforcement Bars.......... 412
Specifications for Constructing Pre-Molded Concrete Piles.......... 415
Specifications for Driving Pre-Molded Concrete Piles.......... 416
  Typical Concrete Pile Sections.......... 418
Designs of Reinforced Concrete Structures.......... 420
Methods of Depositing Concrete Under Water.......... 423
Design of Retaining Walls.......... 425
Monolithic Construction 433
Waterproofing of Masonry.......... 433
Disintegration of Concrete and Corrosion of Reinforcing Material 434
Method of Repairing Defective or Worn Surfaces of Concrete.... 435

SIGNS, FENCES AND CROSSINGS.

Page
Definitions of Terms 437
Specifications for Standard Right-of-Way Fences 438
    Table of Material Required for Fences 443
Gates for Right-of-Way Fences 449
Concrete Fence Posts 449
Surface Stock-Guards 450
Snow Fences, Snow Sheds and Methods of Snow Removal 451
Wooden Crossing Signs 455
Trespass Signs 455
Roadway Information Signs 455

SIGNALS AND INTERLOCKING.

Definitions of Terms 465
Train Order Signals 468
Manual and Controlled Manual Block Signals 469
Indications Conferring or Restricting Rights 472
Division of Expense of Installation, Renewal and Maintenance of Joint Interlocking Plants 472
Signal Indications and Aspects 473
Requisites of Switch Indicators 476
Findings, Conclusions, Standards and Specifications of Signal Section, American Railway Association 477
Signals for Train Operation 487

RECORDS AND ACCOUNTS.

Definitions of Terms 499
Engineering Department Forms 499
    Daily Track Laying Report and Record 501
    Daily Ballasting Report and Record 502
    Resident Engineer's Monthly Estimate of Grading 503
    Resident Engineer's Monthly Estimate of Bridges and Other Roadway Items 504
    Resident Engineer's Monthly Estimate of Buildings 505
    Assistant Engineer's Consolidated Monthly Estimate 506
    Side Track Record (Insert) 508
    Monthly Track Material Report 508
    Monthly Bridge Material Report 509
    Bridge Section Tool Report 509
    Bridge Inspection Report 510
    Current Bridge Inspection Report 512
    Authority for Expenditure Form 513
    Detailed Estimate Form 516
    Register of Authorities for Expenditure 517
    Monthly Report of Expenditures 518

Records and Accounts—Continued. Page

Roadway Completion Report 519
Equipment Completion Report 524
Time Roll 525
Contract and Lease Record 528
Maps, Charts and Profiles 530
Track Chart (Insert) 539
Progress Profile 540
Conventional Signs for Use on Railway Profiles, Right-of-Way and Track Maps 541
Conventional Signs for Signals and Interlocking 554
Reasons for Maintaining a Storehouse 566
Protection of Records 566

RULES AND ORGANIZATION.

Manual of Instructions for the Guidance of Engineering Field Parties 567
Manual of Rules for the Guidance of Employees of the Maintenance of Way Department 571
The Science of Organization 607
Maintenance of Way Organization—Departmental 608
Maintenance of Way Organization—Divisional 609
Rules for Inspection of Bridges, Trestles and Culverts 610

WATER SERVICE.

Definitions of Terms 625
General Principles of Water Supply Service 628
Impounding Reservoirs for Railway Purposes 634
Water Meters for Use in Railway Water Service, Methods for Testing and Reading Meters, and Checking Consumption of Water 639
Water Service Organization 642
Instructions for Care of Water Stations 645
Examination Questions for Care of Boilers 648
Examination Questions for Care of Internal Combustion Engines 650
Examination Questions for Care of Electrically Operated Pumps 653
Quality of Water—Method of Treatment 654
Water Softeners 655
Design and Installation 655
Operation, Maintenance and Supervision 655
Capacity 656
Relative Economy 656
Reagents 656
Foaming and Priming 657

WATER SERVICE—Continued. PAGE

Minimum Quantity of Scaling and Corrosive Matter Which Will Justify Treatment 658
Water for Drinking Purposes 659
Specifications for Wooden Water Tank 660
Specifications for Tank Hoops 663
Steel Sub-Structures for Water Tank 666
Timber Sub-Structures for Water Tank 666
Specifications for Steel Water and Oil Tanks 667
Water Service Records 676

YARDS AND TERMINALS.

Definitions of Terms 681
General Requirements of Yards and Terminals 683
Car Capacity of Freight Tracks 688
Team Delivery Yards 689
Hump Yards 689
Yard Lighting 692
Freight Transfer Stations 692
Passenger Terminal Stations 692
Typical Situation Plans for Division Engine Terminal 693
Transfer of Lading of Bad-Order Cars 693
Catechism of Yard Design and Operation 694
Specifications for the Manufacture and Installation of Railway Track Scales 696
Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales 716

IRON AND STEEL STRUCTURES.

Inspection of Bridges and Records of Inspection 725
Instructions for the Mill Inspection of Structural Steel 725
Instructions for the Inspection of the Fabrication of Steel Bridges. 727
Instructions for the Inspection of Bridge Erection 730
Column Tests 732
Column Formula 732
Requirements for the Protection of Traffic at Movable Bridges... 733
Specifications for Bronze Bearing Metals for Turntables and Movable Railway Bridges 735
Contracting for Steel Railway Bridges 737
Specifications for the Erection of Railway Bridges 737
General Specifications for Steel Railway Bridges 742
Rules and Unit Stresses for Rating Existing Bridges 787
Classification of Bridges for Operating Purposes 790
Principles for Detailed Design of Flashing, Drainage, Reinforcement and Protection for Waterproofing Purposes 791

ECONOMICS OF RAILWAY LOCATION.

Page
Definitions of Terms 800
Economics of Railway Location.................................. 800
Power 805
Train Resistance 814
Curvature 817
Curve Resistance—Freight Cars 817

WOOD PRESERVATION.

General Requirements of Wood Preservation..................... 818
Grouping of Timbers for Antiseptic Treatment................... 819
Specifications for Grade 1 Creosote Oil........................ 819
Specifications for Grade 2 Creosote Oil........................ 820
Specifications for Grade 3 Creosote Oil........................ 821
Specifications for Creosote-Coal-Tar Solution.................. 821
Precautions to be Followed in the Purchase and Use of Creosote-Coal-Tar Solution.. 822
The Use of Coal-Tar in Creosote................................ 822
Specifications for Creosote Oil Analysis....................... 823
Specifications for Zinc-Chloride............................... 835
Specifications for Preservative Treatments of Wood............. 835
  General Requirements... 835
  Zinc-Chloride.. 836
  Zinc-Tannin Treatment.. 837
  Creosote Oil (Full Cell Process)............................. 838
  Zinc-Chloride and Creosote Oil............................... 839
  Creosote Oil (Empty-Cell Process with Final Vacuum).......... 842
  Creosote Oil (Empty Cell Process with Initial Air and Final Vacuum).. 843
Methods of Accurately Determining Absorption of Creosote Oil and Creosote-Coal-Tar Solution................................. 844
Water in Creosote 844
Method for Determining Strength of Zinc-Chloride Solution...... 846
Directions for Use of Iodine Potassium Ferricyanide Starch Color Reaction Tests for Determining Zinc Chlorine Penetration... 848
Determination of Zinc in Treated Timbers....................... 848
Forms for Reporting Inspection of Timber Treatment............. 850

ELECTRICITY.

Definitions of Terms... 853
Overhead Clearance Lines for Permanent Way Structures on Electrified Railways... 854
Clearance Lines for Equipment and Permanent Way Structures Adjacent to Third Rail and for Third Rail Structures......... 855
Railway Specifications for Electric Light, Power Supply and Trolley Lines Crossing Steam and Electric Railways......... 861

ELECTRICITY—Continued. PAGE

Tables and Curves of Conductors Sags.......................... 877
Steel Wire—Stranded—Galvanized 884
Specifications for Wood Poles................................. 887
Specifications for Galvanizing or Sherardizing.................. 889
Stone Conduits.. 902
Railway Specifications for Electric Wires and Cables............ 903
Railway Specifications for Underground Conduit Construction for Power Cables.. 932
Tungsten Lamp Standards..................................... 951

CONSERVATION OF NATURAL RESOURCES.

Rules for the Prevention of the Spread of Forest and Field Fires.. 952

UNIFORM GENERAL CONTRACT FORMS.

Form of Proposal.. 954
Form of Construction Contract................................. 955
Form of Bond.. 967
Form of Industry Track Agreement.............................. 968
Form of Agreement for Interlocking Plant....................... 972
Form of Agreement for Crossing of Railways at Grade........... 979
Form of Lease Agreement for Industrial Site.................... 986

STANDING COMMITTEES.

PAGE
I. ROADWAY 17
II. BALLAST 69
III. TIES 95
IV. RAIL 109
V. TRACK 155
VI. BUILDINGS 239
VII. WOODEN BRIDGES AND TRESTLES 281
VIII. MASONRY 369
IX. SIGNS, FENCES AND CROSSINGS 437
X. SIGNALS AND INTERLOCKING 465
XI. RECORDS AND ACCOUNTS 499
XII. RULES AND ORGANIZATION 567
XIII. WATER SERVICE 625
XIV. YARDS AND TERMINALS 681
XV. IRON AND STEEL STRUCTURES 725
XVI. ECONOMICS OF RAILWAY LOCATION 800
XVII. WOOD PRESERVATION 818
XVIII. ELECTRICITY 853
XIX. CONSERVATION OF NATURAL RESOURCES 952
XX. UNIFORM GENERAL CONTRACT FORMS 954
XXI. ECONOMICS OF RAILWAY LABOR ....
XXII. ECONOMICS OF RAILWAY OPERATION ....
XXIII. SHOPS AND LOCOMOTIVE TERMINALS ....

SPECIAL COMMITTEES.

PAGE
CLASSIFICATION OF RAILWAYS 15
STRESSES IN RAILROAD TRACK ....
STANDARDIZATION ....
CLEARANCES ....

GENERAL RULES FOR THE PUBLICATION OF THE "MANUAL."

Title.

1. The title of the volume will be "Manual of the American Railway Engineering Association."

Discretionary Powers of Board of Direction.

2. The Board of Direction shall edit the Manual and shall have authority to withhold from publication any matter which it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

Adoption of Reports Not Binding.

3. Matters adopted by the Association and subsequently published in the Manual shall be considered in the direction of good practice, but shall not be binding on the members.

Contents.

4. The Manual will only include conclusions relating to definitions, specifications and principles of practice as have been made the subject of a special study by a Standing or Special Committee and embodied in a committee report, published not less than thirty days prior to the annual convention, and submitted by the Committee to the annual convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association. Subjects which, in the opinion of the Board of Direction, should be reviewed by the American Railway Association, may be referred to that Association before being published in the Manual.

5. All conclusions included in the Manual must be in concise and proper shape for publication, as the Manual will consist only of a summary record of the definitions, specifications and principles of practice adopted by the Association, with a brief reference to the published Proceedings of the Association for the context of the Committee report and subsequent discussion and the final action of the Association,

Revision.

6. Any matter published in the Manual may be amended or withdrawn by vote at any subsequent annual convention, provided such changes are proposed in time for publication not less than thirty days prior to the annual convention, and in the following manner: (a) Upon recommendation of the Committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, made to the Board of Direction.

7. The Manual will be revised either by publishing a new edition or a supplemental pamphlet as promptly as possible after each annual convention.

SPECIAL COMMITTEE.

[1]CLASSIFICATION OF RAILWAYS.

Class "A" includes all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 150,000; or, Passenger car mileage per year per mile of district, 10,000; with maximum speed of passenger trains of 50 miles per hour.

Class "B" includes all districts of a railway having a single main track with a traffic that is less than the minimum prescribed for Class "A," and that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 50,000; or Passenger car mileage per year per mile of district, 5,000; with maximum speed of passenger trains of 40 miles per hour.

Class "C" includes all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

---

[1] Vol. 7, 1906, pp. 331, 340; adopted by letter-ballot, June, 1906; Vol. 8, 1907, p. 15.

COMMITTEE I.

ROADWAY.

[1]DEFINITIONS.

General.

Classification.—Arranging the material in groups according to its character.

Contract.—A written agreement between two or more parties specifying terms, conditions, etc., under which certain obligations must be performed. (Specifications are a part of the contract.)

Estimate (noun).—A statement showing probable cost of a proposed piece of work.

(a) Progress Estimate.—An estimate made from time to time showing work performed or material furnished as the work progresses.

(b) Final Estimate.—An estimate made from final checked quantities showing work performed and material furnished upon which final payment is made.

Estimate (verb).—The act of making an estimate.

Quantities.—The amount of material to be handled, expressed in the usual units.

Slide.—The movement of a part of the earth under the force of gravity.

Specification.—That part of the contract describing the materials for or the details of construction.

Stock-Pass.—A culvert or bridge opening under the track, primarily for the passage of stock.

Unit Price.—The price per unit of the various quantities specified in a contract for which a certain work is to be performed.

Washout.—The carrying off of the permanent way by the impact and erosion of waters.

Right-of-Way.

Right-of-Way.—The land or water rights necessary for the roadbed and its accessories.

Roadbed.—The finished surface of the roadway upon which the track and ballast rest.

---

[1] Adopted, Vol. 7, 1906, pp. 341, 442, 443; Vol. 11, Part 2, 1910, pp. 1063, 1087; Vol. 16, 1915, pp. 566, 1071; Vol. 22, 1921, pp. 697, 1051.

ROADWAY.—That part of the right-of-way of a railway prepared to receive the track. (During construction the roadway is often referred to as the "grade.")

STATION GROUNDS.—Property to be used for station purposes.

Technical.

ALINEMENT.—The horizontal location of a railway with reference to curves and tangents.

CENTER LINE.—A line indicating the center of an excavation, embankment or track.

CONSTRUCTION STATION.—A distance of 100 ft. measured along the center line and designated by a stake bearing its number.

CONTOUR.—The line of intersection of a horizontal plane and the surface of the ground.

CROSS-SECTION.—A vertical section of the ground at right angles to the center line.

CENTER STAKES.—Stakes indicating the center line.

ELEVATION OR HEIGHT.—The distance of any given point above or below an established plane or datum.

FINISHING STAKES.—Final stakes set for the completion of the work.

GRADE (verb).—To prepare the ground for the reception of the ballast and track.

GRADE LINE.—The line on the profile representing the tops of embankments and the bottoms of cuttings ready to receive the ballast; and is the intersection of the plane of the roadbed with a vertical plane through the center line.

GRADIENT.—The rate of inclination of the grade-line from the horizontal.

LOCATION.—The center line and grade line of a railway established, preparatory to its future construction.

PLAN.—A drawing furnished for guidance of work.

PROFILE.—The intersection of a vertical plane through the center line with the surface of the ground and the plane of the roadbed, or a drawing representing the same.

SLOPE.—The inclined face of a cutting or embankment.

SLOPE STAKES.—Stakes set to indicate the top or bottom of a slope.

SUBGRADE.—The tops of embankments and bottoms of cuttings ready to receive the ballast.

TOP OF SLOPE.—The intersection of a slope with the ground surface in cuts, and the plane of roadbed on embankment.

Toe of Slope.—The intersection of a slope with the ground surface in embankments, and the plane of roadbed in cuts.

Clearing.

Brush.—Trees less than 4-inch stump-top diameter, shrubs or branches of trees that have been cut off.

Clearing.—Removing natural and artificial perishable obstructions to grading.

Grubbing.—Removing the stumps and roots.

Drainage.

Bog.—Soft, spongy ground, usually wet and composed of more or less vegetable matter.

Channel.—The depression or cut in which a stream is confined.

Culvert.—A covered opening under the roadbed for the passage of water or for other purposes.

Drain.—An artificial waterway for conducting water from the roadway.

Drainage.—The interception and removal of water from, upon or under the roadway.

Ditch.—An open artificial waterway for providing drainage.

Intercepting Ditch.—An open artificial waterway for preventing surface water from flowing over the slopes of a cut or against the foot of an embankment.

Subdrain.—A covered drain, below the roadbed or ground surface, receiving the water along its length by absorption or through the joints.

Trench.—A long relatively narrow excavation the depth of which is greater than its width.

Waterway.—A channel, either natural or artificial, for conducting the flow of water.

Grading.

Average Haul.—The average distance material is to be hauled.

Benched.—Formed into a series of benches.

Berm.—(a) The space left between the top or toe of slope and excavation made for intercepting ditches or borrow pits. (b) An approximately horizontal space introduced in a slope.

Borrow (verb).—To take material from a borrow pit.

Borrow (noun).—Material removed from a borrow pit.

Borrow Pit.—An excavation made for the purpose of obtaining material.

Embankment (or Fill).—A bank of earth, rock or other material constructed above the natural ground surface.

Excavation (or Cutting).—(a) The cutting down of the natural ground surface; (b) The material taken from cuttings, borrow pits or foundation pits; (c) The space formed by removing material.

Foundation Pit.—An excavation made for laying the foundation of a structure.

Haul.—The distance material is moved in the construction of the roadway.

Free Haul.—The distance within which material is moved without extra compensation.

Overhaul.—The number of cubic yards moved through the overhaul distance multiplied by the overhaul distance in units of 100 feet.

Overhaul Distance.—The distance beyond the free-haul limit that material is hauled in constructing the roadway, for which extra compensation is allowed.

Ramp.—An inclined approach.

Settlement (noun).—The term settlement as applied to grading material is the reduction in elevation of an embankment caused by shrinkage or subsidence.

Shoulder.—That portion of the subgrade lying between the ballast covered portion and the ditch in cuts and the top of slope on embankment.

Shrinkage (noun).—The term shrinkage as applied to grading material is the difference in volume between the material excavated and the ultimate volume of the same material in the embankment after it has reached a state of equilibrium, when the latter is the smaller.

Stepped.—Formed with a series of steps.

Subsidence (noun).—That portion of an embankment which has settled below the original surface of the ground.

Swell.—The term swell as applied to grading material is the difference in volume between the material excavated and the ultimate volume of the same material in the embankment after it has reached a state of equilibrium, when the latter is the greater.

Tamped (or Packed).—Packed down by light blows.

Waste.—Material from excavation not used in the formation of the roadway.

Waste or Spoil Banks.—Banks outside the roadway formed by waste.

Tunnels.

Curb.—A broad, flat ring of wood, iron or masonry, placed under the bottom of a shaft to prevent unequal settlement, or built into the walls at intervals for the same purpose.

Rock.—A solid mass of mineral substance.

Shaft.—A pit or well sunk from the ground surface above into a tunnel for the purpose of furnishing ventilation or for facilitating the work by increasing the number of points from which it may be carried on.

Tunnel.—An excavated passageway under ground or water.

Well (or Sump).—A cistern or well into which water may be conducted by ditches to drain other portions of a piece of work.

[2]GENERAL CONTRACT REQUIREMENTS.

(1) Similarity in the form of specifications.

(2) Measurement of clearing and grubbing should be made in units of one hundred (100) feet square.

(3) A threefold classification of materials: "Solid Rock," "Loose Rock" and "Common Excavation," and in special cases such additional classification of material as may seem necessary, such additional classes to be distinctly defined and specified in the contract.

(4) Profiles should be made complete in regard to distribution of material.

(5) The width between center lines of main tracks on tangent should preferably be not less than 13 feet; on curves this distance may be increased.

(6) Rock excavations should be taken out not less than six (6) inches below subgrade.

(7) No waste should be permitted above subgrade closer than ten (10) feet from the slope stakes.

(8) Information on profiles should be so given and arranged that the contractor can intelligently figure the costs of grading in terms as required by the contract.

[3]WIDTH OF ROADWAY AT SUBGRADE.

(1) Class A railways, with constant and heavy traffic, should have a minimum permanent width of twenty (20) feet at subgrade.

(2) In the theory upon which the width of embankment at subgrade is based it is considered that the track, in excavations, is placed upon what is virtually a low embankment; and in order to preserve uniformity of conditions immediately under the track throughout the line, the width of subgrade in excavations should be made the same as on embankments, outside of which sufficient room should be allowed for side ditches.

---

[2] Adopted, Vol. 4, 1903, pp. 32, 35, 39, 44, 66, 74; Vol. 5, 1904, pp. 688, 719; Vol. 6, 1905, pp. 123, 136, 142, 144, 145, 164-173; Vol. 16, 1915, pp. 567, 1075.

[3] Adopted, Vol. 3, 1902, pp. 34, 37, 43; Vol. 6, 1905, pp. 122, 123.

[4]SLOPES OF ROADWAY CROSS-SECTION.

Local conditions and the character of material should invariably be taken into account in determining the permanent slopes of the roadway cross-section.

[5]SPECIFICATIONS FOR THE FORMATION OF THE ROADWAY.

GENERAL.

Alinement.

1. The center of the roadway shall conform in alinement to the center stakes.

Subgrade.

2. The grade-line on the profile denotes subgrade, and this term indicates the tops of embankments or the bottoms of excavations ready to receive the ballast.

Cross-Section.

3. The roadway shall be formed to the section, slopes and dimensions shown upon the standard drawings, or as may be directed from time to time.

Width of Roadway.

4. When finished and properly settled the roadway shall conform to the finishing stakes and shall be of the following dimensions at subgrade, for single track, viz.:

On embankments........................(....) feet wide, and in excavations..............................(....) feet, exclusive of the width necessary for ditches. For each additional track an additional width of..................................(....) feet shall be made.

Slopes.

5. The slopes of embankments and excavations shall be of the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Embankments: Earth—One and one-half to one;
Rock—From one to one, to one and one-half to one.
Excavations: Earth—One and one-half to one;
Loose Rock—One-half to one;
Solid Rock—One-quarter to one.

---

[4] Adopted, Vol. 3, 1902, pp. 34, 45; Vol. 6, 1905, pp. 122, 123.

[5] Adopted, Vol. 4, 1903, pp. 20-29, 33-35, 78-109; Vol. 5, 1904, pp. 675-684, 688, 719; Vol. 6, 1905, pp. 125-136, 143-164; Vol. 11, Part 2, 1910, pp. 1062, 1063; Vol. 16, 1915, pp. 567, 1075.

These ratios may be varied according to circumstances, and the slopes shall be made as directed in each particular case.

CLEARING.

Extent of Clearing.

6. The right-of-way and station grounds, except any portions thereof that may be reserved, shall be cleared of all trees, brush and perishable materials of whatsoever nature.

Disposal of Brush, etc.

7. All these materials, except as hereinafter mentioned, shall be burned or otherwise removed, as may be directed, and without injury to adjoining property.

Stumps.

8. Where clearing is to be done, stumps shall be cut close to the ground, not higher than the stump-top diameter for trees twelve (12) inches and less in diameter, and not higher than eighteen (18) inches for trees whose stump-top diameter exceeds twelve (12) inches, except between slope stakes of embankments, where stumps shall be cut so that the depth of filling over them shall be not less than two and one-half (2½) feet.

Clearing in Advance.

9. The work of clearing shall be kept at least one thousand (1000) feet in advance of grading.

Cutting and Piling Wood.

10. All trees which may be reserved shall be stripped of their tops and branches, made into ties, or cut to such lengths as may be directed, and neatly piled at such places on the right-of-way as may be designated, for which service payment shall be made by the tie, or by the cord of one hundred and twenty-eight (128) cubic feet.

Isolated Trees, Buildings, etc.

11. Where isolated trees, or where buildings exist, payment shall be made for the removal thereof at a price to be agreed upon before removal.

Measurement.

12. Measurement of clearing and payment for the same shall be by units of one hundred (100) feet square, or fraction thereof, actually cleared.

GRUBBING.

Extent.

13. Stumps shall be grubbed entirely from all places where excavations occur, including ground from which material is to be borrowed as well as from ditches, new channels for waterways and other places where required.

Grubbing shall also be required between the slope stakes of all embankments of less than two and one-half (2½) feet in height.

Grubbing in Advance.

14. The work of grubbing shall be kept at least three hundred (300) feet in advance of grading.

Measurement.

15. Measurement of grubbing shall be estimated upon all excavation actually done, and the space to be covered by all embankments of less than two and one-half (2½) feet in height. Payment for the same shall be by units of one hundred (100) feet square, or fraction thereof, actually grubbed.

GRADING.

16. The term "Grading" in these specifications includes all excavations and embankments for the formation of the roadbed, ditching, diversions of roads and streams, foundation pits, and all similar works pertaining to the construction of the railway, its sidetracks and station grounds.

Work Included—Classification.

17. All material excavated shall be classified as "Solid Rock," "Loose Rock," "Common Excavation," and such additional classifications of material as may be established before the award of the contract.

Solid Rock.

18. "Solid Rock" shall comprise rock in solid beds or masses in its original position which may be best removed by blasting; and boulders or detached rock measuring one cubic yard or over.

Loose Rock.

19. "Loose Rock" shall comprise all detached masses of rock or stone of more than one cubic foot and less than one cubic yard, and all other rock which can be properly removed by pick and bar and without blasting; although steam shovel or blasting may be resorted to on favorable occasions in order to facilitate the work.

Common Excavation.

20. "Common Excavation" shall comprise all materials that do not

come under the classification of "Solid Rock," "Loose Rock," or such other classifications as may be established before the award of the contract.

Finishing Slopes.

21. Slopes of all excavations shall be cut true and straight, and all loose stones in the slopes shall be removed.

Excavation Below Subgrade.

22. Rock excavation shall be taken out....................(....) inches below subgrade and refilled to subgrade with approved material.

Excess Excavation and Slips.

23. Excavation in excess of the authorized cross-section, as well as slides extending beyond the slope lines, shall not be paid for unless due to causes beyond the control of the contractor or his agents. In all cases the surplus material shall be removed by the contractor without delay and the slopes reformed. The classification of the material shall be in accordance with its condition at the time of removal, regardless of prior conditions. The measurement of the material shall be the original space occupied regardless of the classification.

Disposal of Excess Excavation.

24. Where the quantity of excavation exceeds that required to make the embankments to standard cross-section, the surplus shall be used to widen the embankments uniformly, along one or both sides, as may be directed, and no material shall be deposited in waste banks unless such waste be indicated either on the profiles or by written order.

Waste Banks.

25. Where wasting is ordered the material shall, if possible, be deposited below grade-line, and under no circumstances shall the waste bank have its nearest edge within..........(....) feet of the slope stakes of the cutting.

Borrow Pits.

26. Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as may be directed. No material shall be taken from borrow pits, unless such borrow be indicated either on the profiles or by written order.

Approximate Quantities Shown.

27. The classification and quantities shown on the profile exhibited for distribution of material are approximate only, and shall in no way govern the final estimate. The Company reserves the right to increase

or diminish the quantities given without affecting the contract unit prices for the various parts of the work.

Reserving Gravel.

28. Gravel, stone or any other material suitable for special use of the Company, which is found within the excavations, shall, when required, be reserved and deposited in convenient places on the right-of-way, as directed. Other suitable material in the vicinity shall be substituted, as required, to complete the embankments.

Berm in Rock Cuttings.

29. A berm of....................(....) feet shall be left between the top of slope of rock cuttings and toe of slope of the overlying earth.

Intercepting Ditches.

30. Intercepting ditches, when ordered, shall be made at the top of the slopes of all cuttings where the ground falls toward the top of the slopes. These ditches must diverge sufficiently to prevent erosion of the adjoining embankment. The cross-sections and locations of such ditches shall be designated. If required, they shall be excavated in advance of opening the cutting.

Ditches in Cuttings.

31. Ditches shall be formed at the bottoms of the slopes in cuttings, according to cross-sections shown upon the plans, or such modifications thereof as may be directed. They shall be neatly made, clear of obstruction, and at the lower ends must diverge sufficiently to prevent erosion of the adjoining embankments.

Subdrains.

32. Subdrains of tile shall be constructed of the size and location as directed. Trenches for these drains shall be taken out at least...... ....(....) inches below frost line; the tiles shall be laid on a bed which shall be true, with half-round sections, with a filling of at least............................(....) inches of cinders or other suitable material on either side and above the tile, and then covered with ordinary soil to the top of the trench.

Measurement and payment for such drains shall be by the linear foot, according to the diameter of tile, including excavation and refilling; the contractor to furnish all material.

Unsuitable Material.

33. Excavations incident to the construction of the roadbed, ditches, channels and roadways shall be used in forming the embankments. Frozen

or other unsuitable material shall not be permitted to enter into their composition.

Formation in Layers.

34. When directed, embankments shall be built in horizontal layers of........................(....) feet in thickness. These layers must be of the full width of the embankment and built to the true slope, and not widened with loose material from the top. The most suitable material shall be reserved for finishing the surface; large stones shall not be permitted within a depth of at least............(....) feet below subgrade.

Shrinkage.

35. Embankments shall be carried to such height above subgrade and to such increased width as may be deemed a necessary provision for shrinkage, compression and washing. As the embankments become consolidated, their sides shall be carefully trimmed to the proper slopes, and they must be maintained to their proper height, dimensions and shape until the work is finally accepted.

Embankments on Slopes.

36. Where an embankment is to be placed on sloping ground, the surface shall be deeply plowed or stepped. Whenever directed, boggy or unsuitable material shall be excavated so that the embankment shall be on a firm foundation.

Embankments Across Swamps.

37. In crossing bogs or swamps of unsound bottom for light fills, a special substructure of logs and brushwood may be required. The logs forming this foundation to be not less than six (6) inches in diameter at the small ends. If necessary, there shall be two or more layers crossing each other at right angles. The logs of each layer shall be placed close together, with broken joints, and covered closely with brush. The bottom layer shall be placed transversely to the roadway, and shall project at least five (5) feet beyond the slope stakes of the embankment.

Measurements and payment for this substructure shall be by units of one hundred (100) feet square, or decimal thereof, of area covered by each layer.

Filling Trestles.

38. In forming embankments from trestles, the material shall be thoroughly compacted between the trestle bents and around and under all parts of the structure. In case of train filling by means of a temporary trestle, the material shall be uniformly spread in the fill.

Embankments at Trestles.

39. Embankments abutting the ends of trestle bridges shall be brought forward upon the structure a distance of at least............(....) feet, with increased width of....................(....) feet in order to form a full roadbed.

Finishing Subgrade.

40. The subgrade shall be compact and finished to a true plane, thus leaving no depression that will hold water.

Embankments Over Masonry, etc.

41. Material for embankments over or about masonry or other structures shall be deposited in thin layers, and each layer carefully tamped. Special care must be exercised that no excessive strain be placed upon these structures. Only the best material shall be permitted for the purpose of such filling. The contract price for excavation shall cover the cost of obtaining, distributing and packing the material behind, over and around all such structures.

Borrow Pits.

Land Provided.

42. Land for borrow pits or waste banks shall be provided by the Railway Company.

Drainage.

43. Borrow pits shall be connected with ditches and drained to the nearest water course, when required. Unless directed, material shall not be borrowed to a depth that will prevent proper drainage.

Slopes and Berms.

44. Side slopes of borrow pits on the right-of-way shall be the same as used in the cross-section of the adjoining roadway. A berm of not less than....................(....) feet in width shall be left between slope stakes of the embankment and the edge of the borrow pit. A berm of not less than....................(....) feet shall be left between the outside slope of the borrow pit and the right-of-way line. Berms shall consist of the original unbroken ground.

Cross-Sectioning of Pits.

45. Borrow pits shall not be excavated before they have been staked out. Borrowing must be done in regular shape in order to admit of ready and accurate measurement. Borrowing or wasting of material will not be permitted on land set apart for station grounds or for other special purposes, except by written directions.

PRICE AND MEASUREMENT OF GRADING.

Basis.

46. Grading shall be estimated and paid for by the cubic yard at the prices specified for the respective materials. Measurements shall be made in excavation only, except as hereinafter mentioned.

Work Included in Price.

47. The contract price per cubic yard shall include the excavation of the material by any method whatsoever; the loading, transportation and deposit of the same in the manner prescribed by these specifications and in the places designated; the plowing or benching of the slopes, and all other expenses incident to the work of grading.

Haul.

48. Unless otherwise specified, it is distinctly understood that the contract price per cubic yard covers any haul found necessary. No allowance will be made for any so-termed overhaul.

ALTERNATE OPTIONAL OVERHAUL CLAUSE.

(The following alternate optional overhaul clause is recommended to be substituted for clause No. 48 of the Specifications for the Formation of the Roadway in case it is desired to allow overhaul.)

Haul.

48-a. No payment shall be made for hauling material when the length of haul does not exceed the limit of free-haul, which shall be........feet.

The limits of free-haul shall be determined by fixing on the profile two points—one on each side of the neutral grade point—one in excavation and the other in embankment, such that the distance between them shall equal the specified free-haul limit and such that the included quantities of excavation and embankment shall balance. All haul on material beyond the free-haul limit shall be estimated and paid for on the basis of the following method of computation, viz.:

All material within this limit of free-haul shall be eliminated from further consideration.

The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free-haul as above described, shall be the overhaul distance.

Overhaul shall be computed in units of one cubic yard moved 100 feet and compensation to be rendered therefor shall be computed on such units.

In case material is obtained from borrow pits along the embankment and runways constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul shall be determined by multiplying the number of cubic yards so hauled by one-half the round distance made by the team, less the free-haul distance. The runways shall be established by the Engineer.

Embankment Measurement.

49. If it be impracticable to measure borrowed material in excavation, it may be measured in embankment, using the cross-section notes of the embankment, and making a just and reasonable allowance for change in bulk, so that the quantities shall equal the excavation quantities as nearly as possible.

Borrow Classification.

50. No classification or allowance shall be made for loose or solid rock in borrow pits unless specific written instructions are given to the contrary, it being the intent and meaning of these specifications that all borrowed material shall be classified and paid for as common excavation.

TUNNEL EXCAVATION.

Line, Grade and Cross-Section.

51. Tunnels shall be excavated to the alinement, gradients and sections shown upon the plans, or to such modifications thereof as may be directed.

Bottom of Rock Tunnels.

52. The material from rock tunnels shall be taken out.............. (....) inches below subgrade and refilled to subgrade with approved material.

Blasting.

53. Blasting shall be done with all possible care, so as not to damage the roof and sides. All insecure pieces of rock beyond the standard cross-section shall be removed by the contractor.

Excess Excavation.

54. Excavation in excess of the authorized cross-section shall not be paid for.

Price to Include.

55. The price paid for tunnel excavation shall embrace the cost of removal of all materials between the outer faces of the portals. It shall include the loosening, loading, transportation and placing of the materials in embankment or waste banks, as directed. It shall also include whatever materials and labor are required for temporary props, supports and scaf-

folding for the safe prosecution of the work, as well as all expense of keeping the tunnel ventilated and free from water, oil or gas.

Niches or Recesses.

56. Niches or recesses for the protection and convenience of the railway employés shall be provided at designated intervals.

Shafts.

57. The location, number and dimensions of all shafts shall be determined. The excavation price for them shall cover all materials contained within the specified cross-section between the surface of the ground and the connection of the shafts with the tunnel. This price shall also cover all material and labor for curbing and support of the sides of the shafts as may be required, the cost of keeping the shafts ventilated and free from water, oil or gas, as well as the cost of all pumping and hoisting machinery.

Wells or Sumps.

58. Wells or sumps within the tunnel necessary for its permanent drainage shall be made as directed and paid for at the same rate per cubic yard as for tunnel excavation.

Right-of-Way for Roads.

59. The contractor shall, without loss or liability to the Company, construct all roads necessary for his use in the execution of this contract.

Haul.

60. The contract price per cubic yard for tunnel and shaft excavation respectively, cover any haul found necessary in placing the material where designated, within limits agreed upon. There shall be no allowance for any so-termed overhaul.

Clauses Specially Applicable to Revision of Existing Line or Widening for Additional Track.

Safety of and Delay to Train Service.

61. The contractor shall arrange his work so that there will be no interference or delay in any manner with the train service of the Company. He shall be responsible for any damage to the Company's property caused by his acts or those of his employés. Whenever the work is liable to affect the movement or safety of trains, the method of doing such work shall first be submitted for approval, without which it shall not be commenced or prosecuted. If continuous detention occurs to the train service, the Company reserves the right to complete the work at the expense of the contractor after giving him written notice.

Precautions for Safety of Trains and Tracks.

62. Heavy blasting shall not be permitted close to the main tracks, nor shall the contractor be permitted to transport material along or between the Company's tracks, except when properly authorized. Whenever the work as authorized affects the safety of the trains or tracks, the Company shall take such precautions as it may deem advisable to insure safety. The cost thereof shall be charged to the contractor and deducted from his estimate.

When and How Company's Tracks May be Moved.

63. The contractor shall not move the Company's tracks or in any way interfere with them under any circumstances. Whenever it becomes necessary that the main line or sidetracks be moved, it shall be done by the Company, and the actual cost thereof charged to the contractor and deducted from his estimate.

Location of Additional Tracks.

64. The location of the additional track shall be on the .... side of existing line. But whenever it is expedient to change any portion to the opposite side, the altered alinement shall be shown upon the maps or diagrams furnished by the Company, and the contractor shall conform to the same without extra charge.

Plowing Slopes.

65. Wherever the existing embankment of..................(....) feet in height or over is raised or widened, the slope of the existing embankment shall be deeply plowed in order to bind the new material thoroughly to it.

Crossings.

66. Wherever it is necessary for material of any description to be transported across the existing track or tracks, the location of the crossings must be approved. The material and labor of placing and maintaining the same shall be furnished by the Company. The actual cost shall be charged to the contractor and deducted from his estimate.

Watchmen, Operators and Flagmen.

67. Day and night watchmen shall be furnished by the Company at the places it may consider necessary for the safety of the Company's trains and works. The cost shall be charged to the contractor and deducted from his estimate. It is distinctly understood, however, that the providing of such watchmen shall not relieve the contractor from the liability and payment for damages caused by his operations.

Safety Signals.

68. The cost of installment, maintenance and operation of all signals necessary to ensure the safety of trains, consequent upon the contractor's work, shall be borne by the contractor, and all instructions regarding their observance shall be strictly obeyed by him.

General Conditions.

Temporary Fences.

69. Previous to or during the work of grading, the contractor, if directed, shall erect and maintain temporary fences in order to prevent trespass upon the railway or damage to adjoining property.

Crossings, Damage to Property.

70. The contractor shall, at his own expense, make and keep in good condition commodious passing places for public and private roads traversed by the line of railway; and he shall be held responsible for damages of whatsoever nature to persons or neighboring property caused by workmen in his employ leaving gates or fences open, blasting rock, building fires or in other ways. If necessary, the payment of the estimate may be withheld until such damages are satisfactorily adjusted. The intention of the contract is that the Company shall not be held responsible for any claims or losses incurred during the construction of the line due to the operation or negligence of the contractor or his employés.

Changes of Alinement or Gradients.

71. The alinement, gradients and cross-sections of the roadbed, as well as ditches and other incidental work, may be altered in whole or in part, as deemed necessary, either before or after the commencement of the work. But any such change or alteration shall not affect the unit prices specified in the contract; nor shall any such changes or alterations constitute claims for damages, nor shall any claim be made or allowed on account of such changes or alterations.

Snow and Ice.

72. Before beginning and during the progress of the work, the contractor shall remove all snow and ice from between the slope stakes at his own expense.

Bench Marks and Stakes.

73. The contractor shall carefully preserve all bench marks and stakes. In case of neglect to do so, he will be charged with the resulting expense.

Roads.

74. Wherever required, the contractor shall open up a safe road for passage on horseback and foot along the whole or any portion of the work under contract.

Temporary Roads, Trestles, etc.

75. No allowance or compensation whatsoever shall be due or paid to the contractor for any temporary roads, bridges or trestles that he may make to facilitate the work.

Final Clearing Up.

76. Before the work is finally accepted, the contractor shall, at his own expense, clear away from the Company's property as well as from public and private roads and the channels of streams and ditches, all rubbish, surplus blasted or excavated material, camp and work equipment.

Extra Work.

77. The cost of any extra work shall not be considered or allowed, unless such extra work shall have been done by direction, in writing. Such written directions shall in every case contain the rates and methods of payment for said extra work.

Contractor's Risk.

78. The contractor shall take all risks from casualties of every nature, and shall not be entitled to any compensation for detention from such causes. The contractor assumes risk of personal liability and damage to stock, tools and machinery used on the work while on the property of the Railway Company, and the contractor agrees to make no claim therefor which may be caused by the operation of the railway.

Company Defined.

79. Wherever the word "Company" is used in these specifications it designates the..Company.

Contractor Defined.

80. The word "Contractor" is used herein to designate the person or persons undertaking the work referred to in these specifications and drawings.

Work in Charge of.

81. In the foregoing specifications it is understood and agreed that the Chief Engineer of the.................................Company is in charge of the work, and that he may appoint such assistants as he may select. Wherever the specifications refer to the judgment, direction, decision, approval, etc., of any employé of the...............Company,

they designate and mean the Chief Engineer or one of his assistants. The decision of the Chief Engineer shall be final as to the intent and meaning of these specifications.

Specifications Part of Contract.

82. The specifications and general conditions referred to are distinctly understood as being embodied with the contract, the whole forming the entire agreement between the Company and the Contractor.

[6]MECHANICAL SHOVELS; LOCOMOTIVE CRANES AND DRAGLINE EXCAVATORS; SHOVEL METHODS AND OPERATIONS.

In the following matter, too detailed specifications are avoided, it being desired to direct attention to important features of good practice and point out proper methods of study and investigation, by which any competent Engineer may draw his own conclusions and secure the best possible results at minimum cost.

The recommendations which are made are not in the nature of a specification, but are intended as a guide in the selection of this important equipment. Many manufacturers already embody the major part of these features in their standard design, and many others can incorporate them without materially affecting the cost or standardization of their product. Certain features, however, are so important that radical changes in design, to those here recommended, would be a vast improvement in some cases. While it is recommended to buy standard equipment, care should be taken to select that of the best-known and most reliable makers and secure machines embodying as many of the features recommended here as possible. It is also advantageous for the maker to control the manufacture in every detail of all parts going into his finished product. The purchaser should have access to all parts of the manufacturers' plants at all times for purposes of inspection, etc.

Three cardinal points should be given careful attention in selecting machinery for roadway construction. These are in their order:

(1) Care in the selection, inspection and acceptance of all material that enters into every part of the machine.

(2) Design for strength and durability.

(3) Design for production.

The prompt delivery of repair parts and the accurate fit of these parts when received, is of utmost importance. This may be best judged by the general reputation of the different makes upon the market, and the supply of repair parts stocked at the nearest depot of supplies.

---

[6] Adopted, Vol. 18, 1917, pp. 626, 1510.

The machine should be so designed, in proportioning the strength of all parts, that breakage will be avoided. This is especially so with an over-powered engine, as a careless operator may easily wreck his machine.

The engines and other machinery should not be crowded, or unhandy to get at in case of repairs. The open-frame type of engines are the most desirable. All parts, as far as possible, should be free and not interfere with others so as to cause delay either in case of repairs or when moving.

The boilers should have ample capacity to operate continuously under full load, but the pressure regulation should be such as to eliminate danger of overtaxing the engines or other parts of the machine. Where lugs or braces are riveted to the boiler, or where pipe connections are made, the plates should be reinforced.

All parts should be interchangeable as far as possible, and bronze bushings are recommended for bearings in place of babbitt, split bushings being preferred where possible.

Steam Shovels.

The general requirements for steam shovels are either so standard as to require no particular explanation or so very special as to make generalities impossible. A standard size and type of shovel manufactured by a well-known and reliable maker in a general way carries in itself ample guarantee, both in regard to its proper design and in respect to the quality of materials and workmanship entering into its construction. Certain special features, however, are noted that should be carefully borne in mind when purchasing this equipment.

Size.

The size of shovel used for any work must be decided by the character and quantity of excavation and the local conditions. In general, the commonest sizes are 60- to 80-ton shovels for the usual railway work. The following gradient of sizes may, however, be of service: For light grading, up to 25,000 cu. yd. per mile, where a shovel can be used economically, a light revolving shovel is to be desired. For 25,000 to 40,000 cu. yd. per mile, a shovel of 50 tons is a good size. For 40,000 to 60,000 cu. yd. per mile, a shovel of 60 to 80 is well suited. For anything over 60,000 cu. yd. per mile, the shovel may run up to well over 100 tons economically if its transportation is not too expensive, and if the ground is fit to carry the weight on sub-grade during excavation.

Special Specification.

Although it is usually unwise to depart materially from the standard design of a manufacturer in purchasing a steam shovel, mainly on account of the increase in cost resulting from such changes, and the liability of delays and other troubles connected with repairs, yet there are certain special features that are very often worth especially specifying. Also, as these are of distinct general advantage, the universal adoption of such a demand by all members of the American Railway Engineering Association would very quickly make them a standard practice with all reputable manufacturers.

The following list covers the principal items:

(1) As far as practical, all parts now made of cast-iron should be made of commercial cast-steel, except those made of manganese steel or similar alloy.

(2) The following parts should be made of manganese steel or a similar alloy:
  Shipper shaft pinions,
  Rack or dipper stick,
  "A" frame collar,
  Dipper breast, lip, teeth bases, teeth, hinges and latch catch.

(3) "A" frame should have bronze bushing.

(4) Swinging circle should have bronze bushing.

(5) All bearings should have bronze bushings instead of babbitt, split bushings to be used where possible.

(6) All sheaves for either chain or cable to be of steel and interchangeable, with bronze of metalline bushings. Rope sheaves should have turned grooves.

(7) All gears, except the shipping shaft pinion, to be of steel with cut teeth.

(8) Shafts and bearings to be the same size as far as possible.

(9) Both air brakes and hand brakes to all wheels.

(10) Double-bolt yoke design instead of saddle-block "U" bolt.

(11) When "U" bolt is used, the cross-section area should be increased 50 per cent. and flattened to fit the saddle yoke.

(12) An oil pump with forced lubrication in engine room.

(13) Rocking grates in boilers.

(14) All gears and dangerous moving parts to be guarded.

(15) Standard M.C.B. automatic couplings and M.C.B. trucks.

(16) Standard steel grab-irons, foot-steps and ladders outside house, as in freight car.

There are several radical structural changes that might be suggested, but as structural changes reduce the efficiency of shovel runners who are used to standard equipment and very seriously complicate the matter of repairs, such suggestions are not considered desirable here.

Delays.

The greatest cause of delay in steam-shovel work is in the removal of the excavated material. Too great care and attention cannot be given to securing proper and ample equipment in the matter of cars and locomotives, and in the proper systematization of service, track, transportation and disposal. The economic success of a steam shovel depends, above everything else, on having an empty car always ready to replace a loaded one under the dipper. Too great stress cannot be laid on this point. Careful management, thorough organization and unceasing superintendence and foresight only, however, can accomplish satisfactory results even with a thoroughly-equipped plant.

As the plant charge against steam-shovel work is always an important item, especially where the haul is long, requiring a large equipment in cars and locomotives, continuous operation is desirable. For this reason, either three 8-hour shifts or two 10-hour shifts are recommended. Where the service is not too trying on the machinery, three 8-hour shifts are more economical, if they do not upset other parts of the organization. When, however, the work is severe, two 10-hour shifts are preferable, as this arrangement gives two hours between each shift for repairs and overhaul in the plant. For night work, where electricity is not available, a small turbo-generator set, similar to that used on a locomotive, can be set up on the shovel for lighting the immediate works.

An old locomotive tender is a very valuable adjunct to a steam shovel, especially where delays may be caused from irregularity in coal and water supply.

The greatest cause of stoppage in the shovel proper is due to carelessness or incompetence in the operator. He should see that his engine-room and all moving parts are kept thoroughly cleaned and accessible. He should train his pit gang to watch the under-gearing and track. He must see that his boiler is washed out as often as necessary, depending on the water used, and that his flues, heads and sheets are tight and in repair. He must continually inspect all parts liable to wear or extraordinary strain and make renewals *before* the accident occurs. He must have a light and accurate hand on the propelling lever and must judge his load on the hoisting chain or cable, especially in an over-powered shovel. Heavy breakage in hoisting chains in such a case is almost always due to an unskilled or careless operator. The mechanical delays on a good shovel operated by a good runner are almost negligible.

A good Works' Superintendent or Master Mechanic can develop good shovel runners if he has time and patience. This, of course, is often difficult on railway work, especially in the Maintenance of Way operations. With average runners, the commonest repairs are as follows:

Hoisting cables.
Hoisting chains.
Swinging cable.

Teeth and tooth bases.
Friction bands and blocks.
"U" bolts or double bolts and yoke.
Pinions (especially shipper shaft).
Dipper latch and hinges.
Dipper stick (in hard digging).
Sheaves and pins (especially at end of boom and padlock block).
Shipper shaft.
Crankshaft on boom engine.
Eccentric straps.
Bearings.
Arm jacks.
Rack bolts.
Clevis strap between dipper and bail.
Ordinary engine repairs.
Ordinary boiler repairs.
Ordinary pipe fittings.

In the above list of most common repairs much of the trouble is undoubtedly due to lack of proper inspection and judgment in removing worn parts before they actually break, also to careless handling of the shovel when unusual strains arise in heavy digging. Where a good runner is secured the repairs will be very small. Where the work is near a base of supplies, the stock parts carried may be very small. There are also many repairs that may be made by the job blacksmith without special stock.

Repair parts to be stocked for emergencies when shovel is built as recommended, are as follows:

6 cold shuts for hoisting chain.
3 cold shuts for propelling chain.
1 swinging cable.
1 cable sheave and pin.
1 chain sheave and pin.
1 set teeth.
1 tooth base.
1 clevis strap connecting bail and dipper.
2 bolts for yoke block, or 2 "U" bolts.
1 set friction blocks.
1 pair each size, bronze bushings.
babbitt, if used anywhere.
1 set piston rings.
6 water glasses.
Miscellaneous assortment of packing, bolts, and pipe and fittings.

The following list of tools is generally recommended. The assortment is very complete and may be reduced at discretion, depending on the proximity of other ready means of supply and repairs:

100-lb. Anvil.
1 Axe, chopping, 4½-in.
1 Bar, buggy, 3-ft.
1 Bar, claw.
6 Bars, lining.
1 Bar, slice, fire, 5-ft.

1 Set blacksmith tools.
2 Blocks, snatch, 6-in.
Set of bolt taps and dies, with holders.
1 Brush, chain, long handle.
2 Buckets, G. I., 2-gallon.
1 Cable, ⅝-in., 60 ft. long.
1 Can, oil supply, 1-gallon (kerosene).
3 Carriers, timber.
6 Chisels (two flat, two round, two cape).
2 Containers, oil, 5-gallon.
1 Cooler, water, 8-gallon.
2 Cups, drinking, enamel.
1 Cutter, pipe.
1 Cutter, gage glass.
Set of twist drills.
1 Flue cleaner.
Forge, blacksmith, portable (with coal).
1 Gage, track.
1 Pair frogs, rerailing.
Set of taps and dies, with holders.
1 Hacksaw, adjustable, 8-in. to 12-in.
2 Hammers, B. P., 1½ and 2 lb.
6 Hammers, sledge, double-face, 8-lb.
1 Hammer, sledge, double-face, 16-lb.
1 Hoe, fire, 5-foot.
50 Feet hose, canvas, 1¼-in.
2 Jacks, ball-bearing (size dependent on shovel).
1 Lantern, hand.
2 Oilers, long spout.
3 Padlocks.
3 Picks, clay.
1 Pot, tallow.
1 Rake, fire, 5-ft.
1 Ratchet, drill.
1 Saw, crosscut (two-man), 5-ft.
1 Saw, hand, crosscut, 26-in.
1 Screwdriver, 12-in.
6 Shovels, round point, short handle, No. 2.
1 Shovel, scoop, No. 3.
1 Vise, combination, pipe and bench.
4 Wrenches, monkey, 6-in., 8-in., 12-in. and 18-in.
4 Wrenches, Stillson, 6-in., 18-in., 24-in. and 36-in.
1 Set wrenches, single-end, ½-in. to 2½-in.

Air-Operated Shovels.

The use of compressed air on a steam shovel is very common on tunnel and subway work, and is sometimes found in mining. It is not generally economical on outside work on account of the excessive plant charges. Its main object is to eliminate smoke and gas in a confined space where ventilation is difficult and expensive.

The main difference between air and steam operation is that air operation is quicker, and until an operator becomes accustomed to it he is liable to damage his machine, especially in the case of an over-powered shovel. Where air is used the boiler is ordinarily used as a receiver.

Where this has been done, great care must be exercised in cleaning the boiler out completely before steam is used. As the air exhaust is inclined to freeze, a reheater is sometimes necessary. The boiler is sometimes used for this purpose, but great care must be exercised and a separate heater is preferred. Coke is the common fuel. Reheating, while an economy, is not generally advisable, on account of the gases, unless absolutely necessary.

Electric Shovels.

Electricity is sometimes applied to shovels as an operating power, but this is not in common use and has not yet met with general approval. It may, however, be readily applied to almost any standard shovel. The action is apt to be very sudden and the control sometimes unreliable, or at least difficult to an ordinary operator. The great irregular peaks in the power consumption is also a serious factor as regards cost and in its effect on lights and other machinery on the same circuit. If power is purchased, care should be taken as to how the contract is worded in this respect.

The commonest application is in the case of light revolving shovels, which use a single motor and friction drive. There are more of these shovels electrified than all the other types put together, and in this case seems to give good satisfaction. Of the heavier shovels, there are comparatively few cases of electrification. Where this occurs, however, the three- and four-motor drive is the most common practice.

On the whole, electric shovels are so little used and under such general discussion, even among the electrical manufacturers, that they may still be said to be in the experimental stage and not subject to definite recommendation. When, however, electric power is cheap, or other circumstances indicate the advantage of its adoption, a special study and investigation is advised.

Electro-Hydraulic Shovels.

Electricity may very logically be applied indirectly to shovel operation. This is especially possible by means of hydraulic pumps and rams. This has been successfully done and the most desirable results obtained. By this means absolute control of the operation is obtained, with full power at all speeds, and the electric power curve will be gratifyingly uniform. No standard design has been devised for this type of shovel, however, so that its use will develop only gradually.

Gasoline Shovels.

Gasoline motors are sometimes used to drive shovels, especially in the light revolving types, such as ditchers. The general application, however, seems far from imminent, and, like electrification, should be considered specially when occasion arises. The most logical application would be in arid regions where water is scarce and of poor quality for boiler purposes.

Tunnel Mucker.

One type of mechanical shovel that deserves special mention is the mucking machine, adapted to small tunnels and headings. Here the head-room is very low, often less than six feet, and the lateral clearance is equally restricted. Often the heading progress is entirely dependent on the mucking, especially where free drilling rock is encountered. The best type of machine for this purpose seems to be an electrically-operated shovel that casts directly back onto a conveyor, which in turn elevates and conveys the muck to cars in the rear. It must be remembered that all machines of this sort are subjected to "congested design" and liable to break down and delay. This form of shovel, like the electric shovel, is still in a rather experimental stage and not subject to definite recommendation.

LOCOMOTIVE CRANES—INDUSTRIAL.

Stability.

One of the greatest difficulties encountered when purchasing Locomotive Cranes arises from the absence of any standard rating for size and stability. At present, the term "15-ton crane," for instance, means absolutely nothing. As a matter of fact, the 15-ton crane of one make often has greater stability under equal loads and radii than a 20-ton crane of another. It is, therefore, recommended that the Association establish a standard rating, so that when a purchasing agent buys a 15-ton crane, American Railway Engineering Association rating, he knows exactly what he is getting in regard to capacity and stability. With this in view, the following general specification is recommended:

"The rating of a locomotive crane shall be given as the net tons that it will lift, at a 12-ft. horizontal radius, with the crane turned in any direction, the center of gravity remaining not less than three inches inside of the gage line of the track, when the water tank and coal bunkers are empty and neither rail clamps nor outriggers in use. Furthermore, the center of gravity shall also remain at least three inches inside the gage line of the track, with the crane turned in any direction, when the boom is raised to its highest position, the load removed from the hook, the water tank and coal bunkers full, and neither rail clamps nor outriggers in use."

Thus: A 15-ton crane is one that will raise 30,000 lb. under the conditions just described, and which will equally retain its stability without load, as described.

It is also very important that the center of gravity of a crane, under working conditions, be as low as possible, and that the load be as closely concentrated about the center of rotation as possible, i. e., the main counterbalance or ballast should be in the non-rotating lower frame and the overhang of the rotating part be as small as possible. This will require a much heavier crane for a given rating than is often now the case, but will reduce the probability of overturning, which is the source of the greatest damage in locomotive crane operations.

Special Features.

Besides the above matters of rating and stability, there are certain features that are very important in crane design and construction. The following should be borne in mind when selecting a crane for any service where heavy duties and absence of delays are important:

(1) On all, except most restricted yard and shop services, two 4-wheel M.C.B. trucks are most strongly recommended. The wheel base should be as long as possible, and the trucks of very heavy pattern, to withstand the concentrated load on side lifts. M.C.B. automatic couplers with spring-draft mechanism should also be furnished. Standard safety appliances as required by statutes must be provided. Air and steam brakes and hand brakes should also be supplied.

(2) The best propelling mechanism is so designed that all gears are in perfect mesh under all circumstances, i. e., on straight and curved track and under shock, except when purposely disconnected for train haul.

(3) The large rotating gear ring and pinion should be of the best quality steel with cut teeth; forged steel without welds is preferred. The slip-ring design is recommended. It must be remembered that the whole weight of crane rotator and load is carried on this ring and ample bearing should be provided, either in rollers or trunnions, especially under the boom end of the frame.

(4) All parts of the crane mechanism should be readily accessible. That is, the engines, drums, shafting, gearing, and especially the clutches, should be so placed that each may be individually repaired or replaced without other dismantling.

(5) All shafts should be of nickel steel, the same size, and with interchangeable bronze bushings, as far as possible. Split bushings are preferred, where possible.

(6) Drums should be interchangeable, as far as possible.

(7) Drums and sheaves should be large. This greatly increases the life of the cables.

(8) All gears should be of steel, with cut teeth.

(9) All castings should be of steel, where practical. Where cast-iron frames and beds are used, these should be very massive and properly webbed and filleted. Where steel frames and beds are used, however, care must be taken that actual strength and rigidity are not sacrificed to economy in weight.

(10) All sheaves should be of steel, with turned grooves, interchangeable, and have bronze or metalline bushings.

(11) Bolts and rivets at the rotating center should be avoided.

(12) No clutches or friction should be exposed to the weather.

(13) The levers should be simply and conveniently arranged and so located that the operator has a good view of his work.

(14) When the crane operates on parallel tracks, where a side swipe is possible from a passing train, convex mirrors should be so fixed as to give the operator a view back of his crane.

(15) All gears and dangerous moving parts should have safety guards.

(16) Boiler tubes must be replaceable without removing the boiler.

(17) The boom should be built up with the flanges of angles, channels, etc., turned in so as to expose the solid corner to possible blows and abuse.

Special Application.

A very valuable application for a locomotive crane, in excavation, is in combination with a steam shovel in deep, narrow cuts, where the spoil may be dumped at the side. The steam shovel may, in such a case, work at a high face in the cut, loading into large buckets, which would be picked up and dumped by the cranes traveling on the side of the cut above. This eliminates all complications usually incident to transportation and disposal under such circumstances.

It should also be remembered that a drag bucket may be used on a locomotive crane. When this is done, an extra large boom is usually erected and the rail clasps and outriggers put into service. The heavier sizes of crane are best adapted for this service, but even then the smaller sizes of drag bucket are recommended, and great care must be exercised by the operator not to put undue strain upon the frame and machinery.

Operator.

As in a steam shovel, the operator is responsible for most accidents and breakdowns. If careless, reckless or incompetent, he may upset or wreck his crane, even under the best operating conditions. Absolute cleanliness, careful inspection and the prompt replacement of worn parts before breakage occurs, as well as good judgment in handling loads, are the fundamental requirements for a successful and economical crane operator.

Drag-Line Excavators.

The drag-line excavator is an attempt to create a locomotive crane that will equal a steam shovel in capacity and handle certain classes of excavation for which a steam shovel is not suited. In this it has been partially successful, although under ordinary conditions and in heavy digging, the steam shovel is by all means the most popular. Where, however, the digging is light and may be deposited directly into the spoil bank without transportation, or where there is very much water or unstable bottom to contend with in the cut, the drag line finds its most useful field. Probably the greatest value of a drag-line excavator is in canal work, or sometimes on side borrows in railway work, especially where the digging is not too heavy and water is encountered.

In purchasing such equipment, only the most reliable and experienced manufacturers should be dealt with, and, where possible, it is advised to correspond with or personally discuss the actual performance of their individual machines with the users.

Regarding the construction details, the recommendations for locomotive cranes generally apply to drag-line excavators except in clearly distinct features, which are self-evident. The rotating circle is much larger. The propelling and traveling mechanism is very varied and deserving of study and careful consideration. The types of bucket are varied and the success of their application depends largely on the nature of their use. In general, a large amount of manganese steel should go into these buckets, especially where rock and boulders are to be encountered.

It is probable that with time and experience, drag-line excavators will become more highly perfected, the cost of maintenance will be greatly reduced and their use will become more general in all classes of work. At present they are still in the early stage of their development, as compared, for instance, with the steam shovel. With this in view, definite recommendations are not now considered expedient.

Methods of Handling Steam-Shovel Work.

Locomotives.

The type and size of locomotives used on steam-shovel work must depend on the character of the work, weight of trains, the length of haul and the local conditions. On maintenance work, ordinary road engines are usually well suited, especially if an ample tail track is provided in the pit so that too much shunting is not required. On construction, where the track is apt to be bad and curves abrupt, the four- or six-wheeled saddle-tank type is preferable, at least near the shovel. If the haul is long and the track is fair, heavier locomotives should be used in transportation.

In general, on construction where the tracks are inclined to be rough and curves sharp, the shorter the wheel base on a locomotive the better, within limits. Where road engines, or even heavy switch engines, are used, there is always danger of derailments and frame breakage. Where "dinkeys" are used, it is well to pay special attention to springs, brakes and the location of the center of gravity with reference to the wheel base. Some makes are so balanced that under heavy loads and on steep grades, two wheels are sometimes lifted clear off the track, with the natural resulting delays, if not damage.

Track.

The shovel track should be made up of 6-ft. sections, with strap connections. Bridles of ½-inch by 2-inch iron should be used, with wedge grips. A notched tie should be used as a check, behind the front trucks, supported by steel saddle clamps attached to the rail with wedged grips. Similar clamps should be placed before the front wheel without tie check. Nothing less than 60-lb. rail should be used under a shovel, and heavier rail should be used under the larger models. No spikes are used.

On the muck track in tunnels standard-length rails are used, spiked to the ties. Where no tail track is possible and the excavation is at a breast, drive rails are very useful. These consist of half-length rails laid on their sides, with the ball of the rail against the inside of the web of the last rail spiked down. As the breast is cleared away, these short rails are driven ahead and the cars are run out on the balls of the capsized rails. When a half-length is thus driven out, it is turned right side up and spiked lightly in position and the other half-length driven out in a similar manner. When both half-lengths have thus been driven out, both are removed and a standard-length rail spiked down in their place.

All track should be standard gage for outside work.

Cars.

Two-way side-dump cars are the most useful in general excavation. The best sizes are 12 to 30 cu. yds. They should be equipped with standard M.C.B. double trucks and be provided with both hand and air brakes. When air dumps are not employed the cars should be self-dumping when loaded, self-righting when empty, and have strong and easily-operated hand brakes, with brake wheels instead of cranks. Where wooden bodies are used, these should be heavily reinforced around the upper rim with steel angles, and steel-plated floors are generally desirable, even in earth excavation. The angle of dump should be as steep as possible within reasonable limits of height and re-righting ability.

When cars of small capacity are used, such as 4 to 10 cu. yds., only four wheels are used, although all cars should be spring-borne. In the case of four-wheeled cars, the wheel base should be long and the trucks articulated, if possible, to avoid derailment. All cars should be very substantially built, steel cars usually being preferred.

In tunnel cars, the wheel base should be fairly long, with spring journals or drop axles, and where they are for heading use, the over-all height should not exceed 4 ft. 6 in. They should be very massively built, with heavy axles, fairly large wheels, steel linings and close clearances. End-dump cars for use on automatic dumping cage or tipple are usually preferred. When such cars are altered for steam-shovel work, the box may be raised to increase the capacity without serious expense.

Convertible cars, which may be used for commercial purposes, are often very valuable, as they may be used both as dump cars and as gondola cars.

Flat cars connected with aprons may be used on steam-shovel work where dumpers are not available. When such is the case, steel aprons are used over the bumpers, and an unloading plow is generally used for the dump. The following points should be observed in the selection of flat cars for steam-shovel work:

(1) The car should be strong enough for the purpose.

(2) Brake-wheels should be in good condition, and in case material is to be plowed off, they should be placed at side of car.

(3) Stake pockets should be in good condition and not spaced too

far apart. Four feet apart in the center of the car, and closer at the ends, is good practice.

(4) Stakes should be strong enough to prevent accident or the derailment of the plow.

(5) The floors of the cars should be kept in good repair.

PLOWS AND SPREADERS.

For handling unloading plows, a cable with an auxiliary engine and drum is recommended. The machine should be able to develop sixty (60) tons pull, steam cylinders, 12 in. by 12 in.; diameter of drum 4½ ft., permitting four wraps of 1½-inch cable to be made. Steam supplied by the locomotive. The winding machinery should be placed on a specially-built or adapted car and protected from the weather.

When raising track, the center plow is recommended when the raise is light; side plows are recommended for making heavy fills or widening the bank.

The plow should be strong and massive. If the mold-board is curved throughout its length so as to make the angle of the entering wedge sharper than that of the tail of the plow, there is less breakage of stakes. The vertical slope of the mold-board should be sufficient to preclude climbing, especially towards the rear, in a side-dump plow. The larger and heavier plows are recommended for general use. The longer the plow and flatter the angle of thrust, the better satisfaction will be gained. The height of the mold-board should not be less than 48 in. on a center plow, or 54 in. on a side plow, and higher plows are usually more desirable.

The size of spreader selected will sometimes depend on special conditions or use, but in general the large size is most useful. For this type of machine the following features are recommended:

Form of spreader, 2 arms.

Pneumatic control by one man.

Maximum spread at least 40 ft., with extension.

Vertical range of wing operation should be about 2 ft. above and below top rail.

Minimum width 10 ft., wings closed.

Maximum height in train 15 ft., wings closed.

Air and hand brakes.

Front plow to flange 2 in. below top rail, with cast-steel cutting edge and manganese steel wearing plates over rail.

The front plow should have extension so that all material on track and 3 ft. to one side may be passed across track to the wing on the other side.

The center of gravity of the car should be as low as possible.

The wings should be heavy, strongly hinged and braced low to avoid twist.

In operation, the trucks should be watched and wheel flanges kept in perfect repair.

The locomotive runner should not be allowed to "charge the pile."

Vertical Limits.

It is impossible to establish set rules regarding the point where lifting track should stop and trestling begin when making embankments with trains. The character of the material is of great importance in the matter of cost. Some engineers consider that it is practically always preferable to trestle or block up the tracks without regard to the depth of fill, while others say it is advisable to raise the track as the fill progresses, up to 25 ft. or more. On the average, from 6 to 10 ft. are the commonest limits. With, however, the great fluctuation in the costs of both labor and materials, it is recommended that each case be treated as an individual problem. The cost of raising should be carefully figured, including the delays and interference caused to and by traffic where such exists, and this set against the cost of trestling, including labor and materials. It should be remembered that in some cases a "run-around" can be formed very cheaply, while in other places this requires either an auxiliary fill or trestle.

In estimating trestle for fills over which regular traffic is not to pass, the length of haul is important. Where the haul is less than two miles, light side-dumping cars may be used, and a very light trestle is required.

Of course, the geographical location of such work also has an important influence on this question, as climate, character and availability of fill materials, labor, lumber and other supplies vary enormously with different sections of the country.

Each engineer, familiar with his own section and the local conditions surrounding the work, is the man to estimate the relative cost and decide where raising track should stop and trestling should commence, either on new location or under existing track and traffic.

BLANK FORMS.

Five blank forms are recommended for reporting steam-shovel operations, as described further on.

No forms are recommended for reporting crane operations, as this is so various and heterogeneous that a standard form is impossible.

No forms are recommended for reporting drag-line excavators, as they are very uncommon on railway work, and when used may be reported on Steam Shovel forms, or a special form modeled on these and made to apply to the individual case.

Of the Shovel Forms recommended, the first two, I. 1 and I. 2, are the reports of the Shovel and Dump Foremen, if the work is done by the railroad forces, or the inspectors, if it is a contract job. They deal purely with field conditions and are to be made out on the work, mainly while it is in progress. The front of the form, besides certain information shown as required at the top, provides space for repair parts, materials and supplies wanted and received and remarks which should act in the nature of a diary. The back is devoted to a tabulation of data and information covering the most important features of operation. Everything on this report, as far as possible, should be checked against the records of the timekeepers, storekeepers, etc., in the job offices. The size of the form is designed, when bound in a book, to fit comfortably into a man's pocket. These forms should be printed on good quality blue and yellow paper, respectively, and bound in books with stiff board covers, opening endwise. The sheets should be perforated at the top so that the forms may be torn out readily when completed. These forms should go to the Job Superintendent, or whoever is in immediate charge of the piece of work, and should also be accessible to the Master Mechanic or person in charge of the job plant as well.

When forms I. 1 and I. 2 have been received from the various units of the job, the distribution clerk compiles form I. 3 based on the information they contain, and from the records of the timekeepers, storekeepers, etc. This is laid before the Job Superintendent, or similar official, to be approved, signed and forwarded to the Division Engineer, or whoever has charge of that division or district. These figures should include everything chargeable to the job, including labor, clerical and engineering staff, material, plant and overhead of the job proper.

At the end of each month, Form I. 5 should be made out and forwarded, as described in I. 3. This is merely a monthly summary of the I. 3 reports.

When the I. 3 forms have been received from all the different jobs of that division or district, the distribution clerk of that office compiles the report shown in form I. 4. This summarizes the information contained in I. 3 forms and is built up in combination with the previous I. 4 forms, so that each interlocks with the one preceding and that immediately following it. When form I. 4 is completed, it is laid before the Division Engineer or other proper official for his approval and signature, after which it is forwarded to the Chief Engineer or Vice-President in charge of construction and maintenance. In making out their report in daily form, the word "month" should be everywhere crossed out.

At the end of each month a monthly report should be made on the same form, I. 4, crossing out the word "day" where month appears and takes its place. This form is made up from the I. 3, I. 4 and I. 5 reports just received and forwarded as described for the I. 4 forms.

In Forms I. 3 and I. 4 average yardage costs are given beside the daily or monthly yardage cost, so that the difference may be seen at a glance as to whether the cost is increasing or decreasing, and explanations be immediately in order. The partial individual summaries of work done also shows the proportion of work completed without the usual analysis and arithmetic.

While these forms may appear superficially elaborate, they are in reality simple and very easily compiled, provided the work is properly systematized and kept up to date. The subjects treated in detail are those most vitally required for successful and economical job operation and supervision, and are designed to give the most valuable information to the parties best able to utilize it. In this connection, the number of carbon copies of Forms I. 3, I. 4 and I. 5 and their distribution to the various officials, other than those directly addressed, must be left to the local authority in that company.

These forms are designed for use on not over two-shift work. Where three eight-hour shifts are used, the forms may be readily altered to suit. No telegraphic report forms are recommended. If such are desired, they must necessarily be so brief and simple that their preparation from these here illustrated is so simple that special recommendation is not thought necessary.

If certain costs show increases that are not accounted for in the report, details may be secured from the distribution clerk, who should have all the individual items going to make up these costs posted and accessible in his distribution book. In the same way, details as to the cost of repairs to different pieces of equipment, the cost of individual supplies, etc., may be secured in the same manner. The distribution clerk should get his data daily from the timekeepers, storekeepers, etc., and should balance up with these separate departments every month. On contract work he should be given access to the above records of the contractor, if such reports are desired. If possible, the man selected for this work should be so constituted that he can maintain amicable relations with the contractor's men under trying circumstances.

(Note.—The forms above described are illustrated on pp. 642-648 of Vol. 18, 1917.)

[5]SHRINKAGE AND SUBSIDENCE.

General.

(1) In determining the allowance for shrinkage to be made in a fill, it should be remembered primarily that it is easier to add to the height of a fill that settles than to lower the track if the settlement does not amount to as much as that anticipated in the original allowance. Therefore, unless the shrinkage of a material is well known in the conditions under which the fill is made, it is best to be well on the safe side; i. e., little or no allowance should be made in height; the extra material, when possible, being deposited where it will be conveniently available for raising the track, as required. The allowance in width should be from about 5 per cent. to 20 per cent. of the height of the fill, depending on the material and conditions.

(2) The material used for fill varies in shrinkage from sound, non-disintegrating rock, or gravel, which is least, to certain swelling clays, which give the greatest shrinkage both in compactibility and erosion at the slopes. While vegetable loam has a large percentage of actual shrinkage, it so quickly produces a protection cover of vegetation that the shrinkage due to erosion is usually small. Where frozen material must be used in making a fill, heavy settlement must be expected, and this is to be avoided where possible.

(3) The material and contour of the ground supporting the fill is also a matter of considerable importance. This is especially so where unstable material is encountered.

(4) The method of making the fill should also be carefully considered. When the tracks are being raised under traffic, the vertical shrinkage will be largely taken care of in the course of the work. When the fill is made by teams or such means as to reasonably tamp and compact the fill in thin layers as it is made, the same is true. Where, however, the fill is made by trestle and without puddling or other method of compacting, the settlement is apt to be considerable.

ALLOWANCE FOR IN ESTIMATING.

Shrinkage.

(1) Figure a shrinkage of 10 per cent. measured in excavation, on earth removed from excavation to embankment.

---

[5]Adopted, Vol. 8, 1907, pp. 307, 308, 349, 350; Vol. 22, 1921, pp. 706, 1051.

(2) Ascertain local conditions and results and use them as a guide in estimating swell of rock, considering nature of formation and method of handling.

Subsidence.

(3) Some subsidence occurs under all embankments built on any ground except rock. It is very light in sand and gravel. The percentage of subsidence is in general greater under small fills than under large ones.

(4) Subsidence is due to compression or displacement of the strata of earth under the embankment.

(5) Subsidence must always be anticipated in swamps, marshes and bogs, and any land on which there is standing water.

(6) Serious subsidence is local and it is impossible to fix any rule as a guide in estimating or anticipating same.

[9]GRADE REDUCTION WORK.

(1) ORGANIZATION.—The simplest organization is preferable. One man should be in responsible charge of the work, with a staff of Engineers and Supervisors to cover the work; the latter should have control of the men, material and means necessary for their respective sections.

(2) The lowest gradient and lightest curvature which physical conditions and the present and prospective business of the railway will warrant should be established.

(3) The location should be completed before entering on the work of construction.

(4) Surface and waterway drainage should be given first consideration, and, lastly, the roadway drainage in excavation.

(5) The grades of railways and highways should be separated wherever practicable.

(6) Temporary bridges should be eliminated by the substitution of permanent structures.

(7) Light, short haul and preparatory work should be done with teams or other light working plant.

(8) Separate tracks for work and traffic should be provided where conditions warrant.

(9) There should be a well-defined plan for conducting heavy excavation before starting work.

---

[9]Adopted, Vol. 9, 1908, pp. 608, 609, 642-648; Vol. 16, 1915, pp. 572, 1081.

[10]TRACK ELEVATION WORK.

(1) Organization.—A Superintendent of Construction should be in complete charge of the work. The following officers in charge of the various branches of the work should report to him: The Engineers having charge of the contract work and giving lines and grades; the Roadmaster in charge of earth work and track work; the Engineer in charge of masonry and bridges; the Yardmaster in charge of engines and switching. An Assistant Trainmaster, with a Dispatcher, in charge of the operation of traffic over the territory covered by the work in hand, may sometimes be required. If the proportions of the work permit, every person connected with the organization should be relieved from all other duties relating to the operation of the railway.

(2) The railway company should handle with its own forces all work which may interfere with the movement of trains.

(3) As far as practicable, all earth work should be handled by machinery.

(4) The best material for use in filling is that which combines low first cost, ease of handling and stability.

(5) Bridgework, during progress of the work, both railway and highway, should ordinarily consist of temporary bridges, to be replaced by permanent bridges after tracks are elevated or depressed.

(6) Water, sewer and gas pipes, electrical conduits and wires should be cared for and moved by the companies owning them, whether or not the expense is borne by the railway company.

[11]WATERWAYS.

The following notes indicate in a general way the information required on survey for waterways:

1. Contour bed of stream.
2. Character bed of stream, mud, sand, gravel, clay, etc.
3. Borings, locate and give character of material found.
4. Direction of current.

---

[10] Adopted, Vol. 9, 1908, pp. 591, 631-642; Vol. 16, 1915, pp. 572, 1081.

[11] Adopted, Vol. 10, Part 2, 1909, pp. 920, 921, 967-1022, 1097-1099; Vol. 16, 1915, pp. 572, 1081; Vol. 21, 1920, pp. 818, 1427.

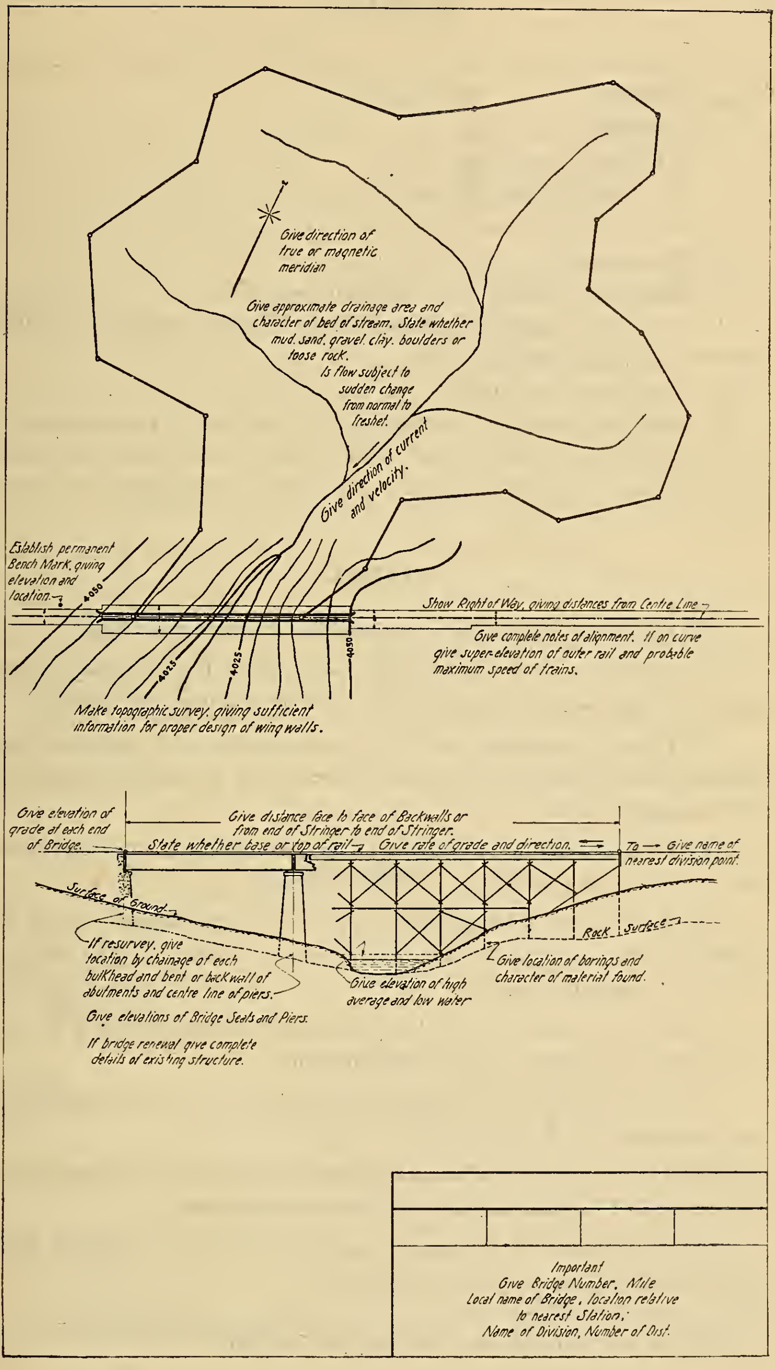

Give direction of true or magnetic meridian
Give approximate drainage area and character of bed of stream. State whether mud. sand. gravel. clay. boulders or loose rock.
Is flow subject to sudden change from normal to freshet.
Give direction of current and velocity.
Establish permanent Bench Mark, giving elevation and location.
4050
Show Right of Way, giving distances from Centre Line
Give complete notes of alignment. If on curve give super-elevation of outer rail and probable maximum speed of trains.
4025
4025
4050
Make topographic survey, giving sufficient information for proper design of wing walls.
Give elevation of grade at each end of Bridge.
Give distance face to face of Backwalls or from end of Stringer to end of Stringer.
State whether base or top of rail
Give rate of grade and direction.
To → Give name of nearest division point.
Surface of Ground
Rock Surface
If resurvey, give location by chainage of each bulkhead and bent or back wall of abutments and centre line of piers.
Give location of borings and character of material found.
Give elevation of high average and low water
Give elevations of Bridge Seats and Piers.
If bridge renewal give complete details of existing structure.
Important
Give Bridge Number, Mile
Local name of Bridge, location relative to nearest Station,
Name of Division, Number of Dist.

FIG. 1.

5. Character of current—slow, rapid, miles per hour. Does flow change suddenly?

6. Elevation.
    (a) High water mark;
    (b) Average stage of water;
    (c) Low water mark.

7. Drainage area.

8. Profile of line, 500 feet minimum each way.

9. If on curve, give full information of curve, superelevation and probable maximum speed of trains.

10. North point and scale.

11. Directions to railway stations, ends of districts or junction points.

12. Plan showing right-of-way with distances from center line, contour lines for a sufficient distance to enable proper design of wing walls, etc.

[12]SLIDES.

(1) Each slide should be considered as a problem by itself.

(2) The cause of the slide should be sought. The removal or prevention of the cause is as important as the restoration of the roadway.

(3) Piles or retaining walls for the prevention and cure of slides are not recommended; but their use is permissible for temporary repairs and in special cases.

(4) Underground water should be drained away or intercepted before it reaches the slide.

(5) The surface of the slide and the restored roadway should be graded so that water will run off and not lie in pools. The surface may be compacted or sodded.

(6) The flattening of the slope is the most economical and permanent method of curing a sliding embankment.

(7) The weighting of the toe of the slope to restore equilibrium may sometimes be found efficient.

(8) The removal of the material is nearly always the most economical and permanent method of curing a slide in excavation.

(9) A relocation of the line is sometimes necessary where the slide assumes the proportion of an avalanche.

---

[12] Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104; Vol. 11, Part 2, 1910, pp. 1064, 1087; Vol. 16, 1915, pp. 572, 1081.

[13]WASHOUTS.

(1) The ends of trestles and bridges should be efficiently protected with masonry, riprap, or other protective work when necessary.

(2) Track should be raised above height of flood waters, if possible, and carried on strong and stable roadbed.

(3) The track on an embankment subject to overflow should be ballasted with heavy angular ballast and anchored. The lower slope of the embankment should be protected with riprap.

(4) Track bridges subject to overflow should be anchored.

(5) If the velocity of the water carries away the riprap or other protection against scour, the width of the opening should be increased.

[14]SURFACE AND SUB-SURFACE DRAINAGE.

(1) Water should be kept off the roadbed if possible.

(2) Intercepting ditches should be constructed for the protection of cuts.

(3) Intercepting ditches or pipe drains should be provided for the protection of banks built on saturated soils.

(4) Side ditches should be constructed in cuts through all classes of materials.

(5) Pipe drains should be provided for the drainage of wet cuts.

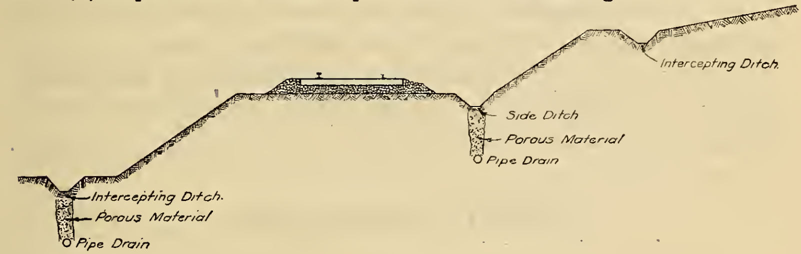


FIG. 2.

[15]TUNNELS.

(1) The forms and dimensions of the clear space to be provided for single and for double-track tunnels on tangent should conform to the

---

[13] Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104; Vol. 16. 1915, pp. 572, 1081.

[14] Adopted, Vol. 10, Part 2, 1909, pp. 921, 922, 1094-1096, 1104-1106; Vol. 16, 1915, pp. 573, 1081

[15] Adopted, Vol. 11, Part 2, 1910, pp. 1065-1097; Vol. 12, Part 3, 1911; Vol. 16, 1915, pp. 573, 1081.

following diagrams (the height of rail in all cases to be assumed as 6 inches):

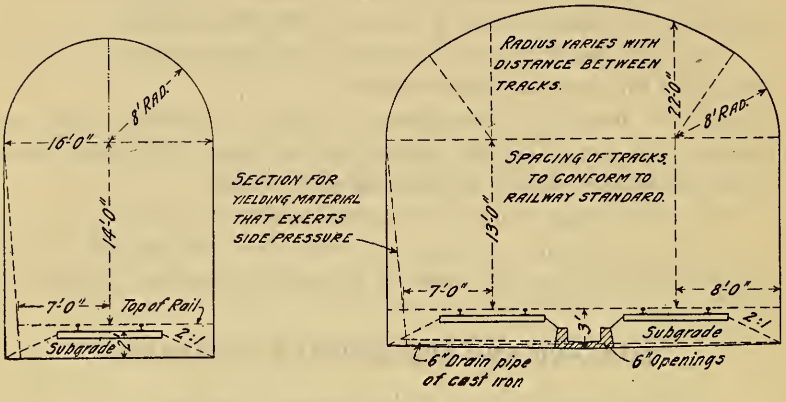

16'0"
8' RAD.
14'0"
7'0"
Top of Rail
2:1
Subgrade
SECTION FOR YIELDING MATERIAL THAT EXERTS SIDE PRESSURE
RADIUS VARIES WITH DISTANCE BETWEEN TRACKS.
22'0"
8' RAD.
SPACING OF TRACKS TO CONFORM TO RAILWAY STANDARD.
13'0"
7'0"
8'0"
3"
2:1
Subgrade
6" Drain pipe of cast iron
6" Openings

Fig. 3.

(2) The dimensions of the section of tunnels on curved track should be increased and the track placed off the center of tunnel sufficiently to give substantially the clearance given above.

(3) Drainage for a double-track tunnel should occupy a concrete channel midway between the tracks.

(4) Concrete should be used for the permanent tunnel lining, except where local conditions will injure the concrete before it sets.

(5) The arch of every brick-lined tunnel should be laid with vitrified brick in rich Portland cement mortar for a width of five feet on each side of the center line of each track.

[16]TUNNEL CONSTRUCTION.

(1) Railway tunnels, as ordinarily constructed, are more economically built by driving the heading entirely through, first, but such method usually requires a greater length of time for completion of the tunnel.

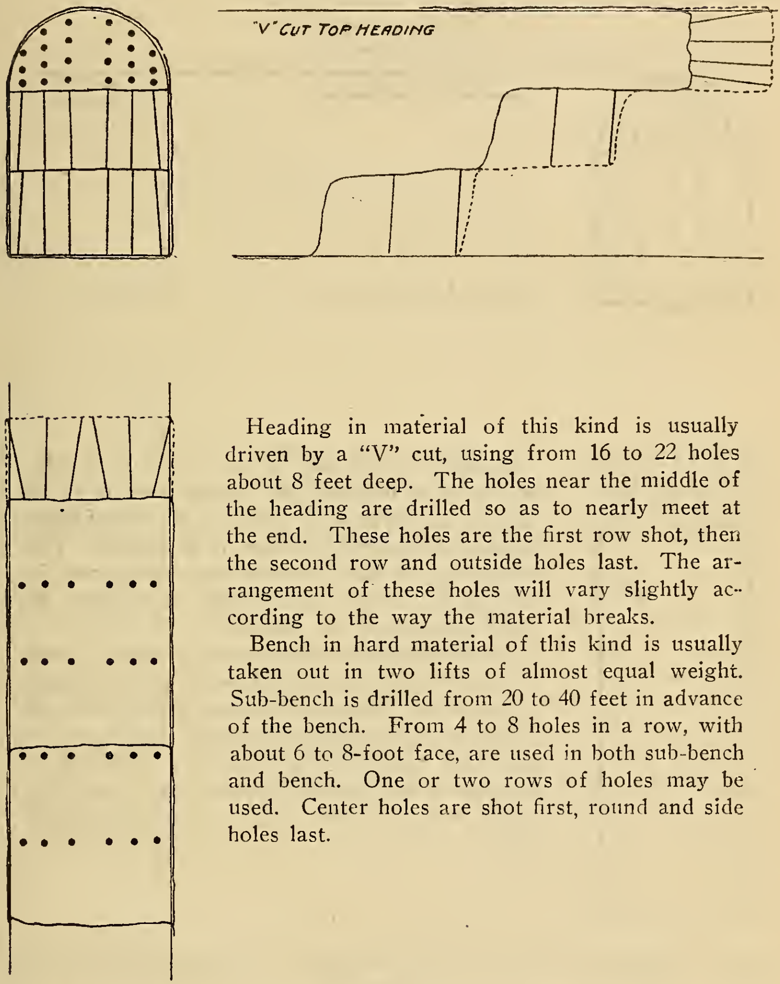
(2) For material requiring support, the top heading should usually be driven.

(3) It is economical and expedient to use an electric shovel or an air-shovel for the removal of the bench, where the section of the tunnel permits the safe operation of the same; and where the material does

---

[16] Adopted, Vol. 15, 1914, pp. 392, 1031.

not require support there are advantages in low cost and quick removal of the bench in driving the heading at the subgrade line.


SINGLE-TRACK SECTION.

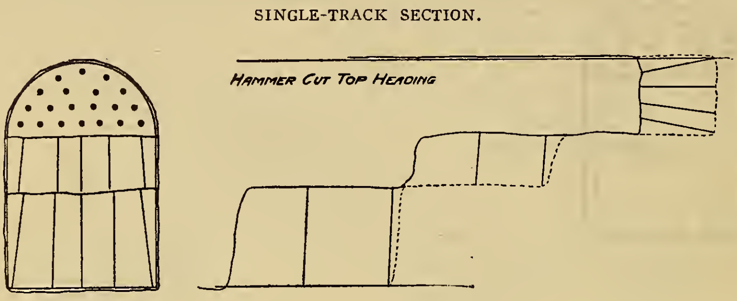
Heading in material of this kind is usually driven by a "V" cut, using from 16 to 22 holes about 8 feet deep. The holes near the middle of the heading are drilled so as to nearly meet at the end. These holes are the first row shot, then the second row and outside holes last. The arrangement of these holes will vary slightly according to the way the material breaks.

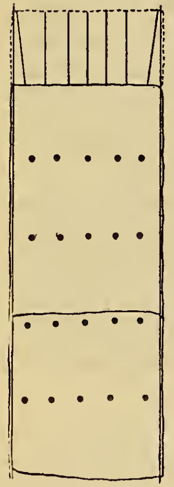
Bench in hard material of this kind is usually taken out in two lifts of almost equal weight. Sub-bench is drilled from 20 to 40 feet in advance of the bench. From 4 to 8 holes in a row, with about 6 to 8-foot face, are used in both sub-bench and bench. One or two rows of holes may be used. Center holes are shot first, round and side holes last.

FIG. 4. METHOD OF TUNNEL CONSTRUCTION IN HARD ROCK WITH FEW SEAMS.

(4) Where the time limit is of value, the heading and bench should be excavated at the same time, the heading being kept about 50 feet in advance of the bench. Where the material of the roof is not self-

supporting and timbering is to be resorted to, the bench should not be removed until the wall-plates are laid and the arch ribs (or centering) safely put up.





Heading in material of this kind is usually driven by a "hammer cut," using from 14 to 20 holes 6 to 10 feet deep. The bottom row of holes is inclined at about an angle of 30 degrees. The bottom row is shot first and each row shown in succession. These holes should be arranged to suit the seams in the material.

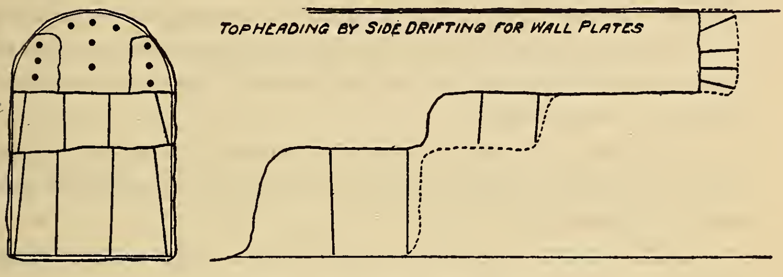
Bench in material of this kind is usually taken out in two lifts, but the sub-bench is not as deep as the bench. Sub-bench is best drilled from 20 to 40 feet in advance of the bench. From 4 to 6 holes in a row may be used with 6 to 10-foot face. The bench is sometimes taken out in one lift. Center holes are shot first, round and side holes last.

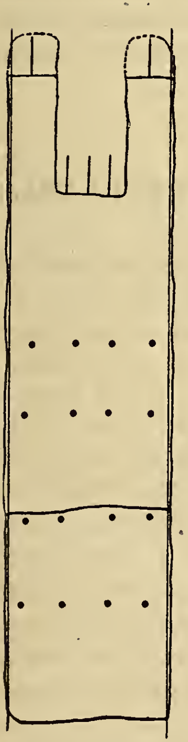
Fig. 5. Method of Tunnel Construction in Moderately Hard Rock with Seams.

(5) Opposing grades should preferably not meet between the portals of a tunnel, so as to put a summit in the tunnel, and where practicable, the alinement and ascending grades in the tunnel should be in the same direction as the prevailing winds.

(6) Figs. 4, 5 and 6 are representative of American practice in single-track tunnel construction, where the time limit is of value.

SINGLE-TRACK SECTION.





This method is only used when material is so soft that heading cannot be driven for full length of timber used for wall plate. Drifts about 4 feet wide and 6 feet high are driven for each wall plate, and then core is taken out as timber rings are put in. Three or four holes may be used from 3 to 5 feet deep in each drift. The amount of shooting necessary depends entirely upon the softness of the material. It can often be picked. The core may be soft enough to pick, or may be shot with from 4 to 8 holes, either drilled from face as shown or from sides of drifts.

Bench in this class of material is shot in one or two lifts. Very few holes are necessary.

Fig. 6. Method of Tunnel Construction in Soft Rock or Hard Clay.

[17]TUNNEL VENTILATION.

(1) The most practicable, effective and economical artificial ventilation for tunnels carrying steam-power traffic is to be obtained by blowing a current of air into one end of the tunnel for the purpose of removing, or of diluting and removing, the smoke and combustion gases at the opposite end. As practiced in America, this way of procuring ventilation partakes of two methods:

(a) To blow a current of air in the direction the train is moving and with sufficient velocity to remove the smoke and combustion gases ahead of the engine;

(b) To blow a current of air against the direction of the tonnage train with velocity and volume sufficient to dilute the smoke and combustion gases to such an extent as not to be uncomfortable to the operating crews and to clear the tunnel entirely within the minimum time limit for following trains.

[18]SPECIFICATIONS FOR SODDING WITH BERMUDA GRASS.

1. The slopes shall be graded to a uniform surface and all depressions filled in with suitable material and padded down firmly with shovel.

2. If the material of the slope is not fertile it shall be given a dressing of 6 inches of good rich loam. If good loam is not available, a dressing of manure shall be placed on the surface and well raked in. Care, however, shall be taken against the use of such manure as have seeds of objectionable grasses or weeds. Before placing the loam the surface of the slope shall be loosened up roughly to insure a good bond. The surface of the slope to be sodded shall be laid out in shallow horizontal trenches 12 inches apart and three inches deep. The Bermuda sod shall be separated into tufts or small pieces not more than 4 inches square and applied in trenches at intervals of 6 inches to a foot apart, according to quality of sod and character of soil, the object being to place only enough of old sod to furnish enough creeping stems to cover the slope in a reasonably short time, thus creating a new sod on the slope in preference to the old sod. The top of the sod shall not extend above

---

[17] Adopted, Vol. 15, 1914, pp. 339, 1034.
[18] Adopted, Vol. 16, 1915, pp. 594, 1083.

the surface of the slope, and if the season is advanced so that it is liable to have hot weather or freezing weather, the sod shall be depressed just below the surface and a covering of loam placed over the soil and loose earth packed firmly around the sod.

3. Sod laid during the day shall be thoroughly watered as soon as practicable after laying and no sod shall be left over night not laid without water. All sod shall be watered daily for 20 days after laying when necessary. On slopes steeper than 2 to 1 the sod shall be in narrow strips 3 to 4 inches wide and 3 feet long and shall be staked to the bank with small stakes 8 inches to a foot long, stakes being placed every foot and a half apart. After the slope has been filled sod shall be rolled or firmly padded down with shovel to a smooth uniform surface. All sod must be taken from good rich soil, be uniform in texture, free from objectionable grasses or weeds and in good healthy condition with no signs of decay and must contain sufficient moisture to maintain its vitality during transportation.

4. Sod shall preferably be cut three feet or more long and eighteen inches to two feet wide and not less than two and one-half inches thick, large pieces of sod being preferable on account of containing their moisture and standing transportation better than small pieces. Sod shall be as fresh as possible and received on the work daily, and any sod to be left over night shall be thoroughly watered; any sod that is heated will not be accepted. All sodding shall be finished before the continued frost sets in.

5. Sod shall be paid for as measured in place, and shall include the entire surface sodded, this price to include furnishing of sod and handling of same. Transportation of sod, men and material also to include stakes where it is necessary to stake the sod. The entire work shall be done in a thorough workmanlike manner to the end that the appearance after completion shall be as nearly as possible that of good natural growth in place.

6. Objectionable grasses and weeds shall be removed from time to time to prevent shading the grasses until such time that the sod has taken hold or the creeping stems have covered the entire slope.

7. Where springs have developed on the slope, a blind drain of cinders or broken stone shall be laid from spring to the toe of the slope.

[19]MEANS FOR PREVENTION OR CURE OF WATER POCKETS IN ROADBED.

(1) Water pockets have existed for many years in certain localities since construction.

(2) They have increased and become more noticeable since the use of heavier equipment and greater density of traffic.

(3) In water pockets the ballast has generally been beaten down into the roadbed and formed a trough under the track, the sub-ballast and roadbed being pushed out laterally and sometimes raised, forming walls, to prevent the water draining from under the track.

(4) Water pockets exist in fills as well as cuts, but more generally in cuts of a clayey nature.

(5) Water pockets exist in localities where soil conditions are unfavorable to satisfactory maintenance, particularly in clay.

(6) Method of surfacing and tamping track has no particular effect in forming water pockets, but the class of material used as ballast does have considerable effect.

(7) Water pockets can be prevented in many cases by proper formation of roadbed and use of proper kind and depth of ballast, as follows:

(a) Where roadbed, in either cuts or fills, is composed of a more or less clayey material, after the work has been brought to a sub-grade, all construction tracks should be removed and the sub-grade rolled with a road roller weighing about ten tons, to a uniformly smooth surface, with either sufficient crown or side slope to shed water; any resulting depression below sub-grade being loosened up with a plow and brought up to sub-grade by the addition of material of the same kind as that composing the roadbed; and then rerolled.

All pipes should be covered 12 in. or more with engine cinders or equally porous material, and then the trench backfilled with the same material as removed if at all porous, otherwise backfill with engine cinders.

After several years' use under traffic it may be necessary to cut through the shoulder of the sub-grade at frequent intervals to afford drainage, as the sub-grade under the track will settle several inches lower than the shoulder.

(b) Sub-ballast should be of good cinder, stone screenings or other similar material, so as to prevent roadbed working up into the ballast proper. Stone ballast should not be used directly on top of clay or loam roadbed.

---

[19]Adopted, Vol. 20, 1919, pp. 416, 880.

(c) Sufficient depth of ballast should be provided to insure even distribution of the load on the roadbed.

(d) Construction trains should not be run, if possible to avoid, over track laid on new roadbed without ballast. This drives the ties into the roadbed and forms depressions, which later on develop into water pockets.

(e) All pipes should be covered 12 inches or more with engine cinders or equally porous material, and then the trench backfilled with the same material as removed, if at all porous, otherwise backfill with engine cinders.

(f) All roadbeds should have sufficient crown to drain properly and the surface should be smooth, and be maintained in this condition until the ballast is placed. Any backfilling necessary to make a smooth surface should be made of the same material as exists in the roadbed.

(g) In buliding new roadbed alongside existing tracks on same grades, care should be taken not to form new roadbed of impervious material at a higher elevation than the original roadbed, but the new roadbed should be kept at or below this level so as to provide an outlet for the drainage through the existing ballast. This is particularly important on hillside construction. If change in existing gradient is to be made, new roadbed for both tracks should be on the same level.

(8) In curing water pockets the principal object is to provide proper drainage. This may be accomplished, according to localities, in several ways, as follows:

(a) In cuts, by means of sub-soil drains of vitrified bell and sewer pipe, laid in ditch or between tracks with uncemented joints. They should be laid at such depth as to be below any movement of the sub-grade and below the water to be drained. They should be below the frost line. Lateral drains of pipes or of cinder or stone may be made to tap the pockets if necessary. All pipes should be covered 12 inches or more with engine cinders or equally porous material, and then the trench be backfilled with the same material as removed, if at all porous, otherwise backfill with cinders.

(b) In cuts where material is very soft to a considerable depth, a drain about three feet square may be provided of large stone, either in the ditch line or between tracks, and of sufficient depth to take the drainage.

(c) In cuts where material is soft to a great depth, old ties or bridge timbers may be driven just outside the ends of the ties. These serve to hold the roadbed in place and to some extent lower the water level, leaving the top surface of the roadbed more firm.

(d) On fills, water pockets should be tapped by lateral ditches and filled with porous material so as to drain.

(e) In many cases the material will have to be excavated and a bed of old timber, cinder or other material spread over the surface to provide sufficient area to prevent the further penetration of the ballast into the roadbed, and the ballast should then be replaced with good, clean material.

[20]DRAINAGE OF ROADWAY THROUGH STATIONS AND YARDS.

(1) The drainage of roadway through stations and yards should be treated in accordance with local conditions.

(2) Surface water should be carried off roadbed into drains as quickly as possible.

(3) Items influencing mode of procedure are: Soil condition, contour of adjacent ground, grade of tracks, number of tracks, amount of rainfall, etc.

(4) Surface water should be taken care of first by open ditches as much as possible, where they will not interfere with the work of employees or the safety of passengers.

(5) Where the sub-grade is of such a nature that it will absorb water and not retain it, a sub-ballast of engine cinders should be used, the surface of which should not be allowed to become foul, but kept open so that water will penetrate the sub-grade through the cinder. Where the sub-grade will hold water, special effort should be made to carry it away from the sub-grade by means of drains.

(6) Tracks in yards should be so constructed where practicable that tracks adjacent to main lines will be about two inches below them and each succeeding track stepped down to suit the normal trend of drainage, thus providing drainage laterally as well as longitudinally.

(7) Cross-drains, with catch basins between tracks, should be placed where necessary.

(8) If the sub-soil is of such a nature that it retains water and be-

---

[20] Adopted, Vol. 19, 1918, pp. 407, 1181.

comes saturated therewith, place bell and vitrified drain pipe or other drains with open joints between tracks, using special care to put them below frost and deep enough to get below the movement of the soil; these pipes running into cross-drains leading to natural drainage.

(9) If sub-soil is silty or of such consistency as to quickly fill up the pipe, a wide ditch should be dug, preferably between tracks, and filled with large stone, having pipes leading off from it to the natural drainage.

(10) At station platforms a sub-drain, with catch basins at frequent intervals, should be laid alongside the curbing, or bell end vitrified pipe may be laid between tracks a sufficient depth to be below frost and movement of the soil. These drains to be connected by means of side drains to natural ditches, or in cuts to bell end vitrified sub-drain laid in the ditch line.

[21]GRADE SEPARATION.

(1) Whenever grade separation through densely built-up thoroughfares (short blocks, say, 12 to 15 crossings per mile), becomes imperative, elaborate studies of the kind and volume of traffic on each thoroughfare should be made and due record kept, with a view of eliminating or vacating certain of these crossings as wholly unjustifiable from a cost standpoint, and lateral streets at a less cost may be opened in their stead.

(2) If but a very few crossings are to be eliminated in an industrial district, with reasonable assurance that no others will be required, other things being equal, the method used should not disturb the tracks.

(3) If several crossings are to be eliminated in an industrial district, other things being equal, the most efficient method is by track elevation.

(4) In a residential district, if grades and other conditions on the railway will permit, complete depression allowing the streets to remain at their original level, or nearly so, is the preferable method.

[22]SLOPES FOR HIGH ROCK CUTS OF FORTY FEET IN HEIGHT OR MORE.

(1) Where the depth of ballast on Class A track is greater than 12 inches under the tie the adopted standard berm should be added

---

[21] Adopted, Vol. 18, 1917, pp. 669, 1510.
[22] Adopted, Vol. 18, 1917, pp. 670, 1510.

to each side of the standard ballast section adopted for the increased depth of ballast. If the sum obtained by the addition of the standard berm to the distance of the toe of the ballast slope from the center of the track ends in a fractional part of a foot, the sum is to be increased or decreased to the nearest whole number of feet.

(2) Rock cuts of forty (40) ft. in height or more should be constructed at slopes of one-quarter to one.

(3) The advisable width for newly-constructed roadbed on high embankments of fifty (50) ft. or more by dumping from the trestle should be as follows (no allowance to be made in height):

Anticipated shrinkage 7 per cent., add 10 per cent. of height to each shoulder.

Anticipated shrinkage 10 per cent., add 15 per cent. of height to each shoulder.

Anticipated shrinkage 15 per cent., add 22.5 per cent. of height to each shoulder.

[23]DRAINAGE OF LARGE CUTS.

(1) More consideration should be given by Locating Engineers to probable drainage conditions in selecting a line contemplating long, low-grade cuts.

(2) If long low-grade cuts are practically unavoidable, Construction and Maintenance Engineers should see that, where practicable, good wide, deep side ditches are provided and maintained.

(3) When not possible or practicable to handle drainage with wide, deep side ditches, sub-drainage should be provided by installing blind rock drains or tiling, as it is impossible to maintain railway track in satisfactory condition unless water is kept drained away from, over, in, around or beneath the track.

---

[23] Adopted, Vol. 22, 1921, pp. 716, 1051.

COMMITTEE II.

BALLAST.

[1]DEFINITIONS.

General.

Ballast.—Selected material placed on the roadbed for the purpose of holding the track in line and surface.

Sub-Ballast.—Any material of a superior character, which is spread on the finished sub-grade of the roadbed and below the top-ballast, to provide better drainage, prevent upheaval by frost, and better distribute the load over the roadbed.

Top-Ballast.—Any material of a superior character spread over a sub-ballast to support the track structure, distribute the load to the sub-ballast, and provide good initial drainage.

Foul-Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, dirt or other foreign matter.

Dust.—Fine particles of sand, clay, loam, or other earthy matter which will pass through a No. 50 screen.

Shoulder.—That portion of the ballast between the end of the tie and the toe of the ballast slope.

Crib.—That portion of the ballast between two adjacent ties.

Depth.—The distance from the bottom of the tie to the top of the sub-grade.

Kinds.

Chats.—Tailings from mills in which zinc, lead, silver, and other ores are separated from the rocks in which they occur.

Chert.—An impure flint or hornstone occurring in natural deposits.

Cinders.—The residue from the coal used in locomotives and other furnaces.

Clay (Burnt).—A clay or gumbo which has been burned into material for ballast.

Granite (Disintegrated).—A natural deposit of granite formation, which on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast.

---

[1] Adopted, Vol. 5, 1904, pp. 486, 495, 498-501; Vol. 6, 1905, pp. 736, 745; Vol. 7, 1906, pp. 83, 84, 88, 100; Vol. 10, Part 1, 1909, pp. 678, 721-727; Vol. 16, 1915, pp. 1005, 1159; Vol. 21, 1920, pp. 426, 1391; Vol. 22, 1921, pp. 78, 957.

Gravel.

(a) Pit Run.—Worn fragments of rock and sand occurring in natural deposits.

(b) Screen.—Worn fragments of rock, occurring in natural deposits, that will pass through a 2½-inch ring and be retained upon a No. 10 screen.

(c) Washed.—A gravel from which foreign matter has been washed and the relative proportions of gravel and sand have been determined.

Gumbo.—A term commonly used for a peculiarly tenacious clay, containing no sand.

Sand.—Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained on a No. 50 screen.

Slag.—The waste product, in a more or less vitrified form, of furnaces, for the reduction of ore; usually the product of a blast furnace.

Stone.—Stone broken by artificial means into small fragments of specified sizes.

[2]CHOICE OF BALLAST.

Natural ballast materials vary greatly in quality, and the choice must often be determined by availability and expediency under the particular existing circumstances.

Financial considerations may control the choice or there may be only one suitable material readily available.

Crushed stone is a manufactured article, and the process being under control, it is practicable to make the product conform to specifications.

In the choice of ballast where gravel is available, it should receive careful consideration, as it has given excellent results, especially when properly screened, crushed and washed.

[3]COMPARATIVE MERIT OF MATERIAL FOR BALLAST.

The following sets forth the relative order of effectiveness of various kinds of ballast:

(1) Stone
  (a) Trap rock.
  (b) Limestone.
  (c) Sandstone.
(2) Washed Gravel

---

[2] Adopted, Vol. 5, 1904, pp. 494, 495, 513, 514; Vol. 6, 1905, pp. 736, 737; Vol. 16, 1915, pp. 1006, 1159; Vol. 22, 1921, pp. 79, 957.

[3] Adopted, Vol. 13, 1912, pp. 95, 949; Vol. 16, 1915, pp. 1007, 1172; Vol. 22, 1921, pp. 79, 957.

(3) Broken Slag (not granulated).
  (a) Precious metal slag.
  (b) Open-hearth slag.
  (c) Blast furnace slag.

(4) Screen Gravel

(5) Pit Run Gravel
  (a) River or stream gravel.
  (b) Hill gravel (not cementing).
  (c) Hill gravel (cementing).

(6) Chats
  (a) Chats from zinc ore, which is coarse.
  (b) Chats from lead ore, which is fine.

(7) Burnt Clay or Gumbo

(8) Cinders
  (a) Hard coal cinders.
  (b) Volcanic cinders.
  (c) Soft coal cinders.

[4]SPECIFICATIONS FOR STONE BALLAST MATERIAL.

Physical Qualities.

General.

1. Stone for use in the manufacture of ballast shall break into angular fragments which range with fair uniformity between the maximum and minimum size specified herein; it shall test high in weight, hardness, strength and durability, but low in absorption, solubility and cementing qualities.

Tests.

Tests shall be made as follows:

2. Weight.—Not less than one-half cubic ft. of the stone accurately measured, and dried for not less than twelve hours in dry air at a temperature of between 125 and 140 deg. Fahr. shall be weighed. The weight shall be not less than............lb. per cu. ft.

(Note.—Of the stone available, that having the maximum should be used; a high quality stone for ballast will weigh 168 lb. per cu. ft.)

3. Strength.—Two-inch cubes of the stone shall be sawed to reasonably accurate dimensions and the top and bottom faces made accurately parallel. For the primary tests, the test specimen shall be dried for two

---

[4] Adopted, Vol. 22, 1921, pp. 93, 957.

hours in dry air at a temperature of between 120 and 140 deg. Fahr. and at the time of test the temperature of the specimen shall be not less than 50 degrees. Tests shall be made in a testing machine of standard form and the stone shall have a compressive strength of .... lb. per sq. in.

(Note.—Of the stone available, that having the maximum compressive strength should be used; a high quality stone for ballast will have a strength of 10,000 lb. per sq. in.)

A secondary test shall be made on specimens the same in all respects as for the primary test except that the blocks shall have been completely immersed in clean water, of a temperature between 35 and 90 deg., for 96 hours, the test to be made within 30 minutes of removal from the water.

If the compressive strength shall have decreased more than .... per cent. from the primary tests, the rock shall be deemed unsuitable for ballast purposes.

(Note.—Of the stone available, that showing the least difference between the results of the primary and secondary test should be used; a high quality stone for ballast should show not over 1 per cent difference.)

4. Solubility.—One-fourth cubic ft. of the rock shall be crushed and thoroughly washed. The particles shall then be placed in a glass vessel and covered with clear water. The vessel shall be thoroughly shaken for five-minute periods at 12-hour intervals for 48 hours. If any discoloration of the water occurs, the rock shall be deemed soluble and undesirable for use as ballast.

5. Wear or Durability.—(*Test No. 1*). One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 in., and exposed to a dry heat of from 125 to 140 deg. Fahr. for a period of two hours. After the dried stone is carefully weighed it shall be given 10,000 revolutions in a tumbler approximately 4 ft. in diameter, of not less than 2 cubic yards capacity, and operating at 25 revolutions per minute.

The sample shall then be passed over a screen of the minimum dimension provided for sizing the ballast, again washed and dried in the same manner as before the test, and again carefully weighed.

If the decrease in weight shall be more than .... per cent. of the original weight of the sample, the stone shall be deemed unfit for use as ballast.

Outside of the breakage, which is exhibited by the small particles which will pass through a minimum screen but will not pass a sieve of 20 meshes to the inch, the wear should not exceed .... per cent.

(NOTE.—Of the stone available, that showing the smallest loss in weight should be used; a high quality stone for ballast will show a loss of not more than 1 per cent in fragments which will pass a screen of 20 meshes to the inch, and not more than 3 per cent in those passing the minimum sizing screen.)

Test No. 2 (Quick Weathering Test). One-half cubic yard of stone shall be dried and weighed as for Test No. 1. It shall then be immersed in water for six hours and then, while still wet, be placed in a refrigerating plant and subjected to a temperature of approximately zero Fahr. for two hours. It shall then be removed and the temperature gradually raised in two hours to 100 deg. and that heat continued for two hours, when it shall be immersed as before and again subjected to approximately zero temperature.

The freezing and thawing shall be repeated to a total of ten exposures. If any tendency to disintegrate is observable the stone should be considered unsuitable for ballast. Otherwise the material shall again be subjected to a wear test as provided under Test No. 1. If in this wear test the maximum decrease in weight shall be in excess of .... per cent. it shall be deemed unsuitable for use as ballast.

(NOTE.—Of the stone available, that showing the minimum average decrease in weight should be used; a high quality stone for ballast will not show a decrease in fragments which will pass the minimum sizing screen of more than 4 per cent.)

6. ABSORPTION.—One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 inches, and exposed to a dry heat of from 125 to 140 deg. Fahr. for a period of 6 hours. After the dried stone is carefully weighed it shall be submerged in clean water for a period of 96 hours. It shall then be removed from water and exposed to a normal air in the shade and at a temperature between 40 and 80 degrees, and allowed to drip for 30 minutes, when it shall again be weighed and the difference in weight shall be used to determine the rate of absorption. Stone showing an absorption of more than .... lb. per cubic foot is unsuitable for ballast.

(NOTE.—Of the stone available, that showing the minimum absorption should be used; a high quality stone for ballast will have an absorption of not more than 0.50 lb. per cu. ft.)

7. CEMENTING QUALITY.—A five-pound sample of the rock thoroughly washed and dried shall be crushed until it will pass through a screen of

one-fourth inch mesh. This material shall be placed in a ball mill which contains two steel shot weighing 20 lb. each, and the mill revolved at the rate of 30 revolutions per minute, until it has made 2000 revolutions for each pound of sample in the mill.

Sufficient clean water shall be added to make a consistent mortar, which shall then be moulded into one-inch cubical briquettes, formed under 10 lb. pressure. All of the briquettes shall then be allowed to dry 20 hours in air, when one-third of them shall be tested for compressive strength.

One-third shall be kept for four hours in a steam bath, and the remainder shall be immersed for four hours in clean water at a temperature between 50 and 60 deg. Fahr. and then tested for compressive strength.

If in any of these tests a compressive strength greater than .... lb. per square inch is developed, the material shall be deemed unsuitable for ballast.

(Note.—Of the stone available, that from which the briquettes show the minimum strength should be used; a high quality stone will show not to exceed 4 lb. per sq. in.)

Requirements.

8. Breaking.—Stone for ballast shall be broken into fragments which range with fair uniformity between the size which will in any position pass through a 2½-in. ring and the size which will not pass through a ½-in. ring.

9. Test for Size.—(*Maximum*). A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars and placed in or on a screen having round holes 2¾ in. in diameter. If a thorough agitation of the screen fails to pass through the screen 95 per cent. of the fragments, as determined by weight, the output from the plant shall be rejected until the fault has been corrected.

(*Minimum*). A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars; weighed carefully and placed in or on a suitable screen having round holes ½-in. in diameter. The screen shall then be agitated until all fragments which will pass through the screen have been eliminated. The fragments retained in the screen shall then be weighed and if the weight is less than 95 per cent. of the original weight of the sample the output of the plant shall be rejected until the fault is corrected.

10. Handling.—Broken stone for ballast must be delivered from the screens directly to the cars or to clean bins provided for the storage

of the output of the crusher. Ballast must be loaded into cars which are in good order and tight enough to prevent leakage and waste of material and are clean and free from sand, dirt, rubbish, or any other substance which would foul or damage the ballast material.

11. Inspection.—Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the ballast material is prepared and loaded in accordance with the specifications and contracts.

In case the inspection develops that the material which has been or is being loaded is not according to specifications, the inspector shall notify the manufacturer to stop further loading and to dispose of all cars under load with the defective material.

As the quarry deepens or is enlarged, further tests shall be made of the material whenever conditions indicate a change in the quality of the stone, or where in the judgment of the Engineer for the Company, a further test is advisable. Should such tests show that the stone fails to meet the provisions of these specifications, it shall not be used for the manufacture of ballast.

12. Measurement.—Ballast material may be reckoned in cubic yards or by tons, as expedient. Where ballast material is handled in cars, the yardage may be determined by weight, after ascertaining the weight per cubic yard of the particular stone in question by careful measurement and weighing of not less than five cars filled with the material, or the tonnage may be determined for subsequent cars by measurement and converting the yardage into tonnage by use of the weight per yard as determined above.

[5]SPECIFICATIONS FOR WASHED GRAVEL BALLAST.

1. Gravel for ballast shall be so prepared that dust, loam and dirt are removed, that all aggregates that will not in any position pass through a 2½-in. ring are rejected; and that the sand contained in the ballast shall not, in volume, exceed 20 per cent. nor be less than 15 per cent. of the material as loaded for use.

The term "sand" where used in these specifications, refers to any hard granular comminuted rock which will pass through a No. 10 screen and be retained on a No. 50 screen.

---

[5] Adopted, Vol. 22, 1921, pp. 98, 957.

Test No. 1. Dust, Dirt or Loam.

2. A sample of the prepared ballast containing one-eighth (⅛) cubic foot shall be placed in a watertight receptacle having a capacity of not less than one (1) cu. ft. Into this receptacle shall then be placed two quarts of clear water after which the receptacle shall be agitated until the gravel is thoroughly washed. The water shall be drained off immediately and placed in a glass jar and allowed to settle. If the sediment deposited in the bottom of the jar is more than one-half (½) of one (1) per cent. of the volume of sample the output of the plant shall be rejected until the fault has been corrected.

Test No. 2. Large Aggregate.

3. A sample weighing not less than 150 lb. shall be placed in or on a screen having round holes 2¾ in. in diameter. If a thorough agitation of the screen fails to pass through the screen 98 per cent. of the material, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.

Test No. 3. Sand.

4. One cubic foot of the prepared ballast shall be thoroughly dried, placed in a screen having ten meshes to the inch and the screen agitated till all particles which will pass have passed through the screen. If the material which passes through the screen exceeds 20 per cent. or is less than 15 per cent. in volume of the original sample the output shall be rejected until the fault has been corrected.

Inspection.

5. In case inspection develops the fact that the material which has been or is being loaded is not in accordance with these specifications, the inspector shall notify the manufacturer to stop further loading until the fault has been corrected, and to dispose of all defective material that had been loaded in cars, which shall be done at the expense of the contractor.

Measurements.

6. When ballast is being paid for by the ton, and it is impracticable to weigh each car, the weight per yard shall be obtained by weighing at frequent intervals not less than five cars loaded with ballast, the contents of which have been carefully measured. The weight per yard

obtained by such a test shall be used in figuring the weight per car until another test is made.

7. When ballast is paid for by the yard, the amount shall be determined by weighing each car, where practicable, and applying the weight per yard as determined by frequent tests. When impracticable to weigh each car, the contents of each car will be carefully estimated by comparison with cars, the contents of which have been actually measured.

[6]SPECIFICATIONS FOR PIT RUN GRAVEL BALLAST.

For Class A Railways: Bank gravel, which contains more than two (2) per cent. dust or forty (40) per cent. sand, should be washed or screened.

For Class B Railways: Bank gravel, which contains more than three (3) per cent. dust or sixty (60) per cent. sand, should be screened or washed. Screened gravel should not contain less than twenty-five (25) per cent. nor more than fifty (50) per cent. sand.

For Class C Railways: Any material which makes better track than the natural roadbed may be economically used.

Method of Testing Quality of Pit Run Gravel for Ballast.

(1) The size of the sample to be tested should be approximately 1 cubic foot.

(2) Five average samples of about 1 cubic foot each should be selected from various parts of the pit which is to be tested. The five samples should then be thoroughly mixed and about 1 cubic foot of the mixture selected for testing.

(3) To separate the gravel from the sand and dust, use a No. 10 screen, ten (10) meshes to the inch, made of No. 24 wire, B. & S. gage. To separate the sand from the dust, use a No. 50 screen fifty (50) meshes to the inch, made of No. 31 wire, B. & S. gage.

(4) Measure the percentage of gravel, sand and dust taken from the sample by volume, giving the percentage of each ingredient compared to the volume of the sum of the ingredients, as follows:

$$\text{Per cent. of sand} = \frac{S}{G+S+D}$$

Where S=Volume of sand.
G=Volume of gravel.
D=Volume of dust.

---

[6] Adopted, Vol. 22, 1921, pp. 81, 957.

(5) When sample is shipped for test it should be carefully and securely marked with name and location of the pit from which it was taken.

[7]SPECIFICATIONS FOR BURNT CLAY BALLAST.

Kind of Material.

1. Good ballast clay is heavy and plastic, free from sand, gypsum or other impurities. It must not crumble when exposed to air or when brought in contact with heat.

Location.

2. The pit should be located on level or moderately sloping ground, not subject to overflow. A water supply is desirable and it should be borne in mind that the sulphurous and carbonaceous gases liberated during the burning period, damage the surrounding vegetation and make habitation in the near vicinity very disagreeable.

Test.

3. The location site should be thoroughly tested to determine quality of clay, depth and uniform consistency of deposit, and small quantities should be burned in test kilns to show the quality of ballast to be secured.

Burning.

4. Fuel should be fresh, clean slack, and arrangements should be made to secure constant supply. One ton of slack coal is generally sufficient for the perfect burning of four cubic yards of acceptable ballast. From one to one and one-half-inch layer of slack is alternated with from ten to twelve-inch layer of clay, a new layer of slack and clay being applied to the fire every five or six days.

Fires once started must be kept steadily and uniformly burning.

To insure thorough and proper burning of the clay, the top and face of the fire should be frequently raked down, to avoid clinker or black spots, caused by too much or too little air.

When fully burnt a proper ballast clay becomes red in color, when the clay contains iron; when under-burnt the clay will show a yellow color.

Size.

5. Burnt clay ballast should be crushed or broken, if necessary, so that the largest piece will pass through a 4-inch ring.

Density.

6. The finished product should absorb not to exceed 15 per cent. of moisture by weight.

---

[7]Adopted, Vol. 22, 1921, pp. 82, 957.

[8]CINDER BALLAST.

The use of cinder as ballast is recommended for the following conditions: On branch lines with light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; as sub-ballast on new work where embankments are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

A sub-ballast blanket of cinders not less than 12 in. thick is effective in most cases in preventing mud and similar material working up into the top-ballast.

[9]PROPER DEPTH OF BALLAST.

(1) On a roadbed material such as clay, loam, etc., subject to deformation by the application of live load, the proper depth of ballast under the tie to produce approximately uniform pressure on the roadbed would be not less than the spacing center to center of the ties. For Class A Track, see Ballast Sections.

(2) On material that approximates the character of good sub-ballast (which will not be deformed by the application of live load), the minimum depth of ballast under the bottom of the tie should be twelve (12) inches.

(3) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to provide against upheaval by frost; to serve as a cushion for the track.

(4) A combination of a good sub-ballast eighteen (18) to fourteen (14) in., and top-ballast six (6) to ten (10) in., making a total of approximately twenty-four (24) in. under the tie in the aggregate, will produce nearly the same result as though the superior material was used for the full depth.

(5) Until sufficient tests are made under normal traffic conditions, the proper depth of ballast under the tie must rest on opinion, based on experience and supported by such tests as are available, notably the test made by Director Schubert of the German Railways and the "Altoona Test" made by the Pennsylvania Railroad.

(6) Proper drainage of the sub-grade is essential to success with any kind of ballast.

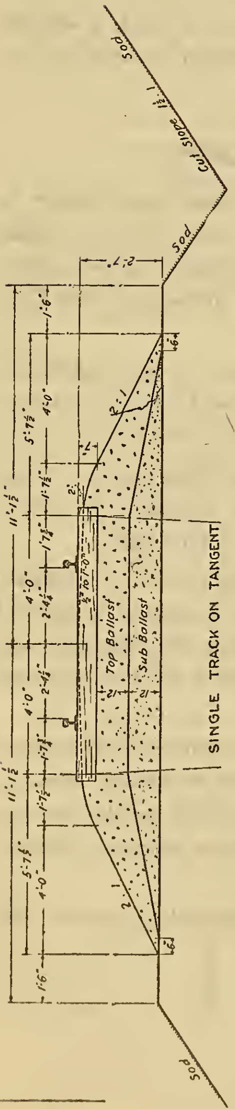
---

[8] Adopted, Vol. 22, 1921, pp. 80, 957.
[9] Adopted, Vol. 22, 1921, pp. 80, 957.

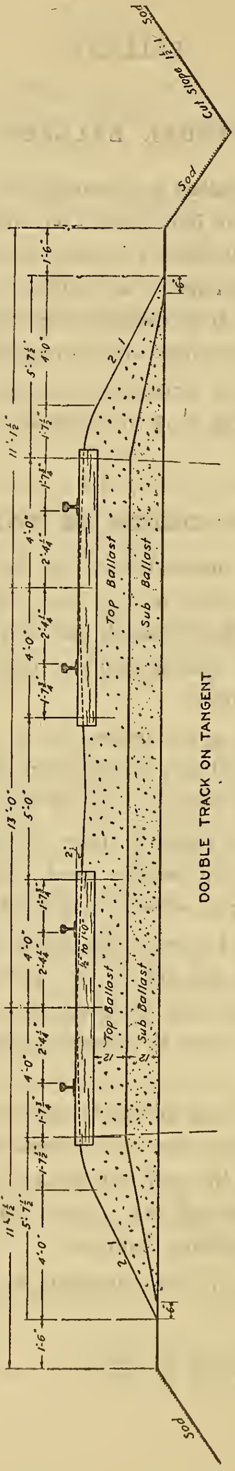
[10]BALLAST SECTIONS, WITH PARTICULAR REFERENCE TO SUB- AND TOP-BALLAST.

Class "A" section should have 24 inches of ballast under the tie.

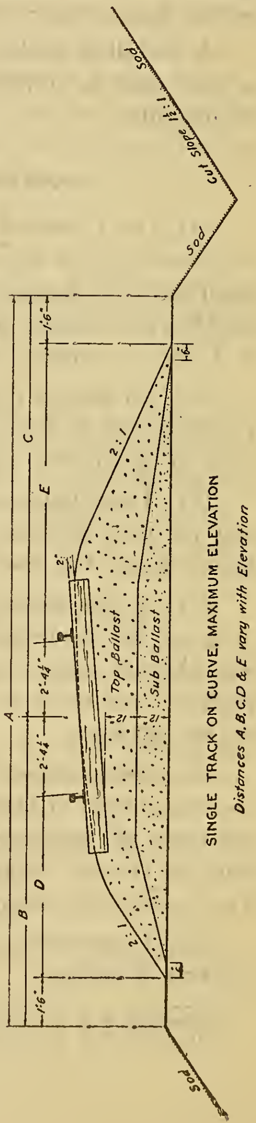
FOR STONE BALLAST.



SINGLE TRACK ON TANGENT



DOUBLE TRACK ON TANGENT



SINGLE TRACK ON CURVE, MAXIMUM ELEVATION

Distances A,B,C,D & E vary with Elevation

---

[10] Adopted, Vol. 8, 1907, pp. 44-46, 62, 65, 66, 67; Vol. 9, 1908, pp. 309, 311; Vol. 16, 1915, pp. 1011, 1170; Vol. 19, 1918, pp. 712, 1187; Vol. 22, 1921, pp. 86, 957.

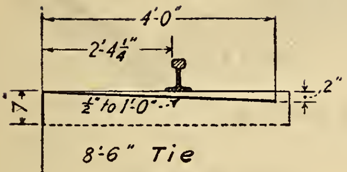


FIG. I

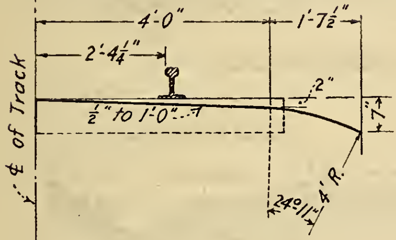


FIG. II

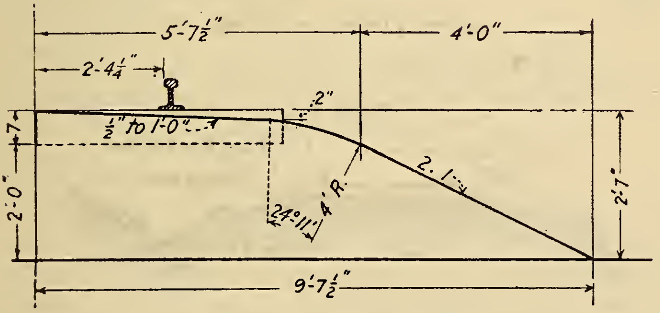
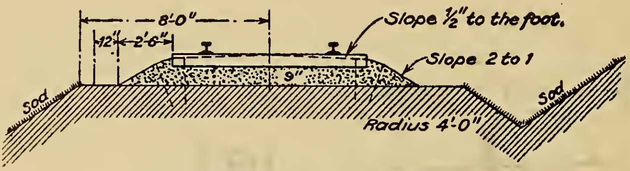


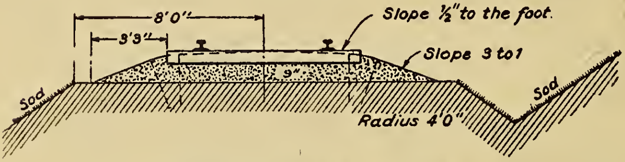
FIG. III

The Sections for Class B track are intended to show minimum depth under ties and are recommended for use only on the firmest, most substantial and well-drained subgrades.

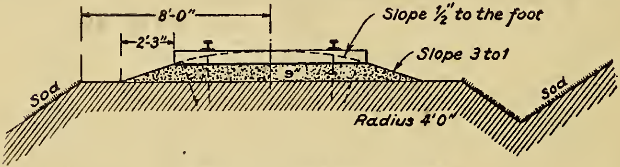
CLASS B.



Crushed Stone and Slag.

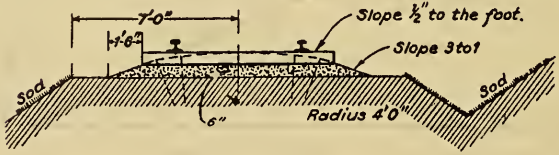


Gravel, Cinders and Chats.

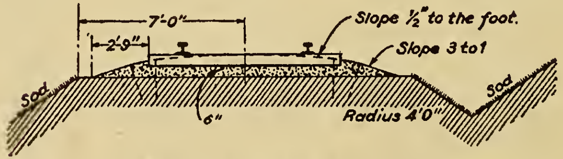


Gravel, Cinders and Chats.

CLASS C.



Cementing Gravel and Chert.



Cementing Gravel and Chert.

[11]INSTRUCTIONS TO GOVERN BALLASTING ON AN OPERATED LINE.

Authority.

Decision of the kind and amount of ballast to be applied having been made by the proper officials, the work should be handled as follows:

Plans.

The Division Engineer or Roadmaster, whichever is to have responsible charge, shall lay his plans for work-train movements and service before the Trainmaster and Chief Dispatcher, in order that they may have a clear understanding of what is desired to be done, and that they may be able to assist the movements to be made with as little delay as possible.

Ballast Supply.

If the ballast is to be furnished by the Company or from a pit for which the Company is responsible, a careful inspection of the pit tracks and appurtenances shall be made and everything put into serviceable condition.

Equipment.

All equipment, such as steam shovel, mechanical unloader, unloading plows, material spreader, ballast plow, or spreader, etc., shall be gone over and put into working order.

Protection.

Speed restrictions shall be arranged for in accordance with operating rules before the track is disturbed, and shall be maintained until the track is in safe condition for schedule speed.

Preparation of Roadbed.

Preparatory to placing ballast, the roadbed shall be widened, if necessary, to bring it to the A.R.E.A. standard width, by dumping material alongside of the track and spreading it to the required width and slope, preferably by the use of a material spreader. Where necessary to raise the roadbed level, porous material must be used to avoid the forming of water pockets by burying in of old ballast.

Bank Widening.

All bank widening shall be done far enough in advance of the ballasting work so that there will be no interference between work-trains or gangs.

---

[11] Adopted, Vol. 22, 1921, pp. 89, 957.

Skeletonizing.

After the banks have been widened, the track shall be skeletonized. Where the material is suitable for sub-ballast and the grade will permit, the track shall be raised and the old material spread under and between the ties, and to the proper width, as uniformly as is practicable.

Where conditions do not permit of raising the track, the old material shall be removed to the required depth and disposed of as directed.

Where not suitable for sub-ballast, the old material shall be removed to the plane of the bottom of the ties, or deeper, if necessary, to preserve grade line, and shall be placed on the outer shoulder of the roadbed, preferably at such points as will tend to even up the line of the shoulder.

Use of Jacks.

In using jacks, they must be placed outside the rail and close enough together to prevent undue bending of the rail or overstrain of the joints. Where the roadbed material is heavy or holds to the ties tenaciously, it is sometimes necessary to place three or more jacks per rail length. Jacks should be worked in pairs directly opposite each other, and a sufficient number should be used simultaneously, so that no jack will raise the rail more than 4 in. above its level at the next succeeding jack or place of support.

Tie Renewals.

Following the skeletonizing of the track, such tie renewals shall be made as the Company's standards require. All ties must be properly straightened and spaced.

The track must be fully gaged as the new ties are being spiked up. Old ties must be disposed of as directed.

Grade Stakes.

Ballast grade stakes shall preferably be set after the bankwidening, skeletonizing and re-tieing have been done and before the ballast material has been dumped and spread.

It is desirable to avoid, as far as possible, interference with the stakes, yet to have them available as a guide for the unloading of ballast.

Drains.

All tile, box or other drains required to take care of water from between tracks, shall be placed before the ballast material is unloaded.

Unloading of Ballast.

Ballast shall be unloaded by dumping or plowing as the means provided permit.

If the ballast be in center dump cars, it shall be unloaded by having one or more cars opened a little at a time and allowing the required or desired amount of ballast material to flow out as the train is slowly moved along. If the material be on flat or open-side cars, it shall be plowed off by means of an unloading machine while the train is standing or moving at such a rate of speed as to provide the desired amount of material as uniformly distributed as possible.

The unloaded materials shall be leveled down by means of a ballast plow, or of a spreader, consisting of a heavy timber with wheel skids attached to it, and placed in front of the leading pair of wheels of the rear truck. Care must be taken not to destroy or disturb the grade stakes.

Parallel Tracks.

Where a new track is being built parallel to an existing track, ballast material can be advantageously handled in body dump cars which dump the entire load to the side desired, after which the ballast material may be spread to the required width and depth by the use of a material spreader, and the track laid after the ballast is in place.

Preliminary Surfacing.

The first lift shall be a filling lift.

The filling, or preliminary surfacing gang, shall follow the unloading as closely as the regularity of the ballast supply will permit.

The amount which the track should be raised at one lift will depend upon the depth of ballast to be applied. Usually, track should not be raised more than 6 in. at a lift, but if the total lift of the track is to be not more than 10 in., a first lift of 7 to 8 in. may be made, if traffic conditions will permit, leaving the remainder of the raise for the finishing lift. A sufficient number of jacks must be used simultaneously to avoid damage to rails. The raise on any one jack shall not be greater than 4 in. above the next jack, or point of support. Both rails must be raised at one time, and as nearly uniformly as is practicable.

The "filling lift" shall be made by jacking the track up to the required height, and the ballast material then forked or shoveled in and worked to as uniform a surface as possible by the use of spades. It shall then be left to be compacted by traffic, but a small "lookout" gang shall go over it after a few trains have passed, and pick up any spots that show too great an inequality of settlement.

After a few days, depending upon the amount of traffic over the track, another lift shall be made, either another filling lift or a finishing lift, according to the depth to which the track is to be ballasted. If another filling lift, it shall be made in the same manner as the first one.

Finishing Lift.

When the track has been raised to within two or three inches of the final grade and properly compacted, a finishing lift shall be made by jacking up the track to the exact height provided for by the grade stakes and the necessary ballast forked or shoveled in and then driven to place by the tamping machines, tamping picks or bars, if rock or heavy ballast is used. Shovel tamping should be used with gumbo, cinder or light sandy gravel ballast. In making the finishing lift, the spot board and level board must be used with care, and the track brought to as true a surface as possible.

Alinement.

The track shall be placed in good alinement before the finishing lift is made, but a lining gang shall follow one or two day's work behind the finishing lift and shall spot up all places found not to be holding up to proper surface and shall line the track to as accurate alinement as possible.

Center stakes shall be set for the alinement before the finishing lift is made, and the final alinement must conform to the center stakes.

Dressing.

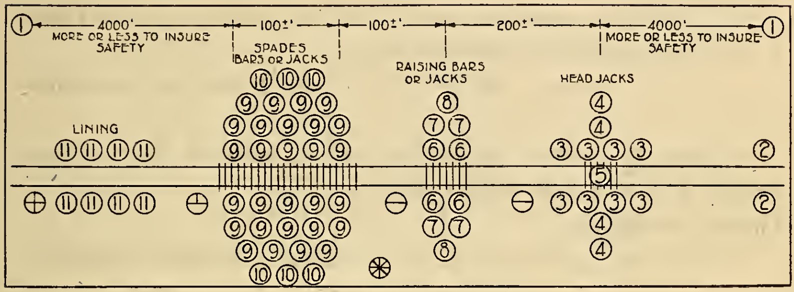
Following as closely as possible behind the lining gang, the dressing gang shall finish the work by filling the track center to the required fullness and then dressing it toward the toe of ballast, preserving the proper clearance under the rail and proper curve and slope of the shoulder. The toe of ballast shall be made a true line, parallel to the center line of track, and any surplus material shall be raked far enough from the toe line to permit of its being forked or shoveled up without fouling or disturbing the finished ballast.

No ballast material or refuse out of the ballast or roadbed material which would interfere with a mowing machine when cutting grass and weeds shall be cast off of the roadbed or be left where it will interfere with the use of mowing machines or scythes.

Clean-up.

When the dressing gang leaves any part of the track as completed, it shall be in first-class line and surface. The ballast shall conform to the ballast sections as adopted by the A.R.E.A. All surplus ballast shall have been loaded, and all refuse and rubbish shall have been removed, loaded or destroyed, so as to leave the right-of-way and shoulders of roadbed in condition to be mowed without interference.

[12]ORGANIZATION AND DISTRIBUTION OF A BALLAST RAISING FORCE OF 77 MEN.



No.	No. of Men	Force
1	2	Flagmen
2	2	Digging Holes for Jacks
3	8	Head Jacks
4	4	Spaders
5	1	Levelman
6	5	Raising Bars or Jacks
7	4	Tampers
8	2	Forkers and Sledges
9	28	Tampers
10	6	Forkers
11	8	Lining and Filling In
	1	Water Carrier
	1	Tool Man
	1	Time and Material Clerk
⊛	1	Foreman Supervising Work
⊖	2	Asst. Foremen Raising Track
⦺	1	Asst. Foreman Tamping
⊕	1	Asst. Foreman Lining Track

Number of Men, 71; Total Force, 77

NOTE.—The diagram presupposes that old track has been skeletonized and that a follow-up gang will do the finished lining and dressing after the track has been pounded down under traffic. The skeletonizing gang should precede the raising gang by about one day's work. Slow order should govern train movements over skeletonized track as well as the track being lifted. Lifting jacks should be set away from the joints, preferably at least two ties. Ties should be respaced if necessary, particularly at the joints.

---

[12] Adopted, Vol. 22, 1921, pp. 85, 957.

[13]SPECIFICATIONS FOR BALLAST TOOLS.

Scope.

1. These specifications cover tamping bars, ballast forks and tamping picks.

Material.

2. These tools, other than straps, shall be high-grade tool steel made by the Open-Hearth or Crucible process.

3. Straps for forks shall be of soft Open-Hearth steel or wrought-iron.

4. Handles shall be smooth and well seasoned, of the best grade straight grained ash or hickory, bent to shape.

Chemical Properties.

5. The steel shall conform to the following chemical composition:

	Tamping Bars and Picks Per Cent	*Forks Per Cent*
Carbon	0.55 to 0.75	0.90 to 1.05
Manganese	0.40 to 0.60	Not more than 0.50
Phosphorus	Not more than 0.04	Not more than 0.04
Sulphur	Not more than 0.04	Not more than 0.04

Design.

6. The dimensions of tools shall conform to the plans which are made a part of these specifications.

Physical Properties.

7. All tools shall be free from defects and finished in a workman-like manner.

8. Tools must be properly tempered to provide the maximum toughness and strength to perform the service for which they are intended.

9. Tamping bars, picks and tines, head and tongue of ballast forks shall be of one piece, no welding being permissible.

10. Tools shall be marked as shown on the plans.

Inspection.

11. Inspection of tools shall ordinarily be made at the place of manufacture. The manufacturer shall notify......................of the Railroad Company at least .... days in advance when tools will be ready for shipment. However, when so directed, in regard to a particular shipment, the manufacturer shall make shipment on his own inspection, subject to requirements of paragraph 15.

---

[13] Adopted, Vol. 22, 1921, pp. 100, 957.

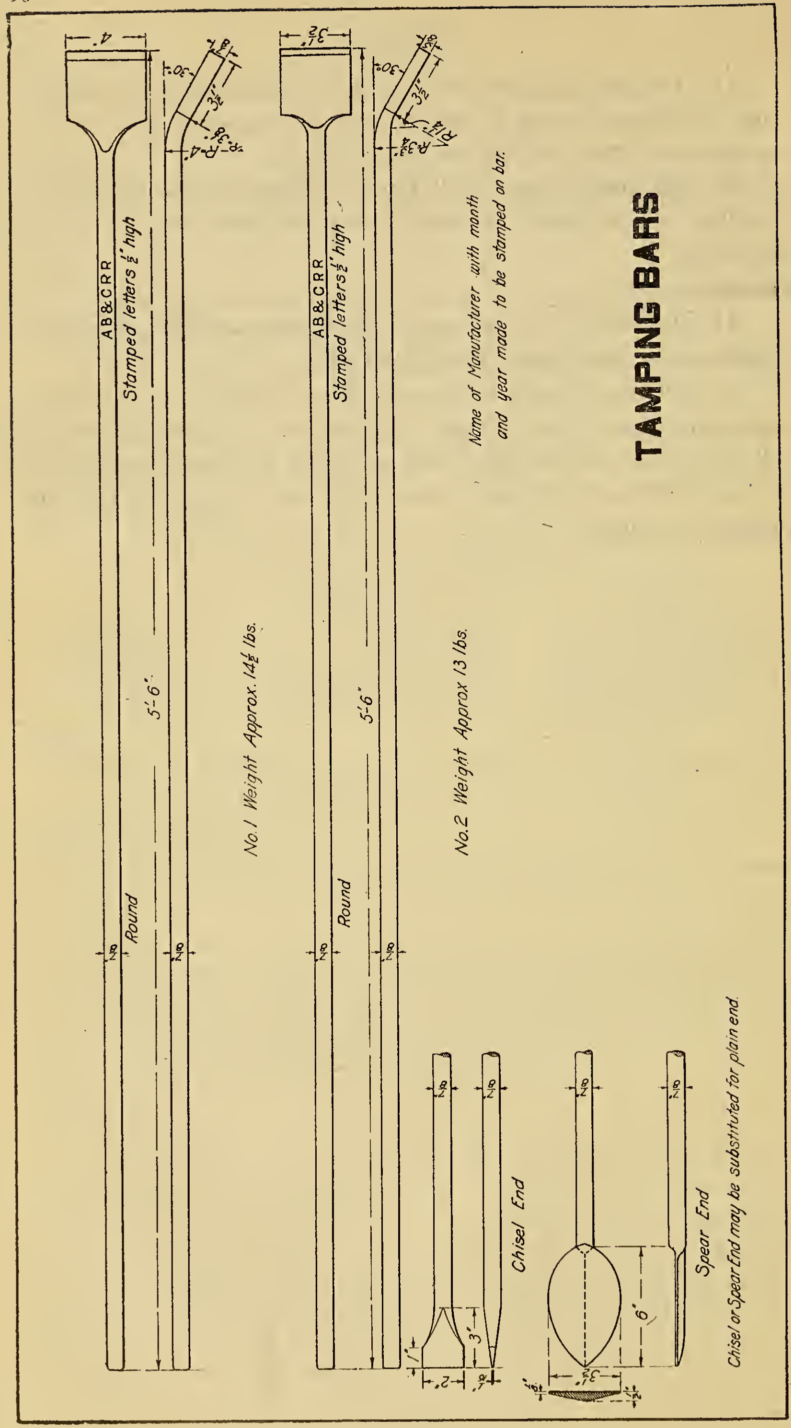
12. The manufacturer shall allow the Railroad Company's inspectors such access to the work as may be necessary to satisfy them that the provisions of these specifications are carried out.

13. The manufacturer shall furnish, without charge, all necessary facilities and assistance for making thorough inspection and tests at the works.

Rejection.

14. Individual tools, defective in any respect, and lots of tools not meeting above requirements, shall be rejected.

15. All tools shipped on manufacturer's inspection, as provided in paragraph 11, which on arrival at destination are found defective and all tools which develop flaws and defects in the usual and necessary service, shall be rejected and replaced at the entire expense of the manufacturer or seller.



TAMPING BARS

AB&C RR
Stamped letters 1/2" high
5'-6"
Round
7/8"
4"
30°
3 1/2"
3 1/2"
No. 1 Weight Approx. 14 1/2 lbs.
No. 2 Weight Approx 13 lbs.
Name of Manufacturer with month
and year made to be stamped on bar.
Chisel End
Spear End
1"
3"
2"
6"
Chisel or Spear End may be substituted for plain end.

BALLAST FORKS

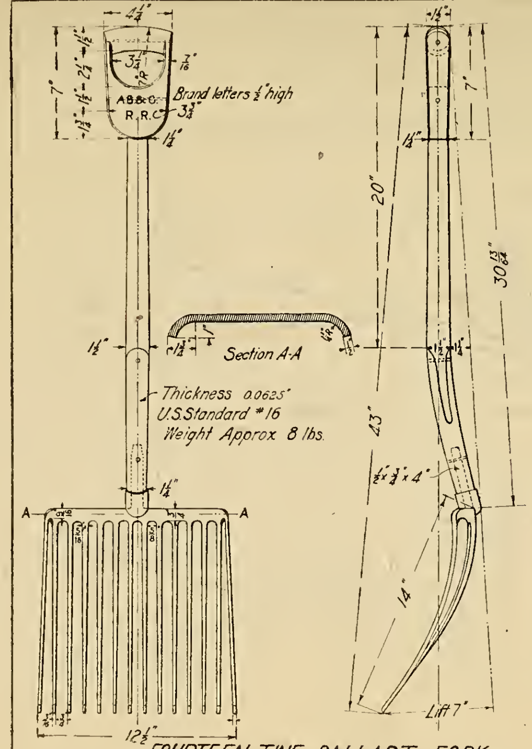
Name of Manufacturer with month and year made to be stamped on strap

The following variations in dimensions shown on plan will be permitted

Length of handle 1"

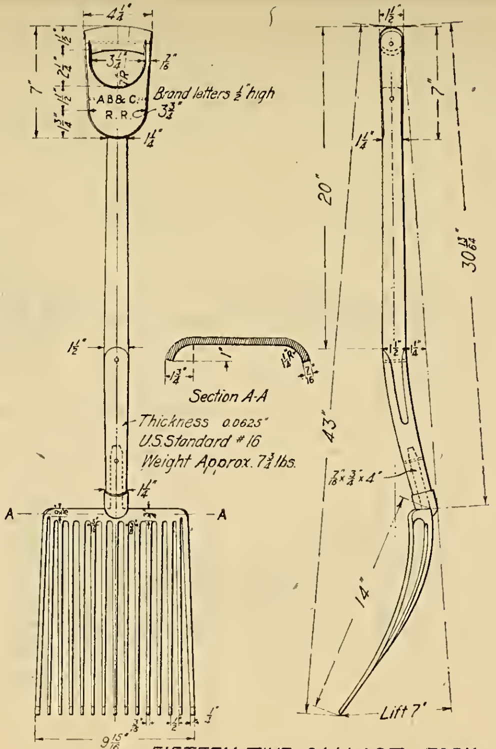
Length of blade ½"

Lift of blade ½"



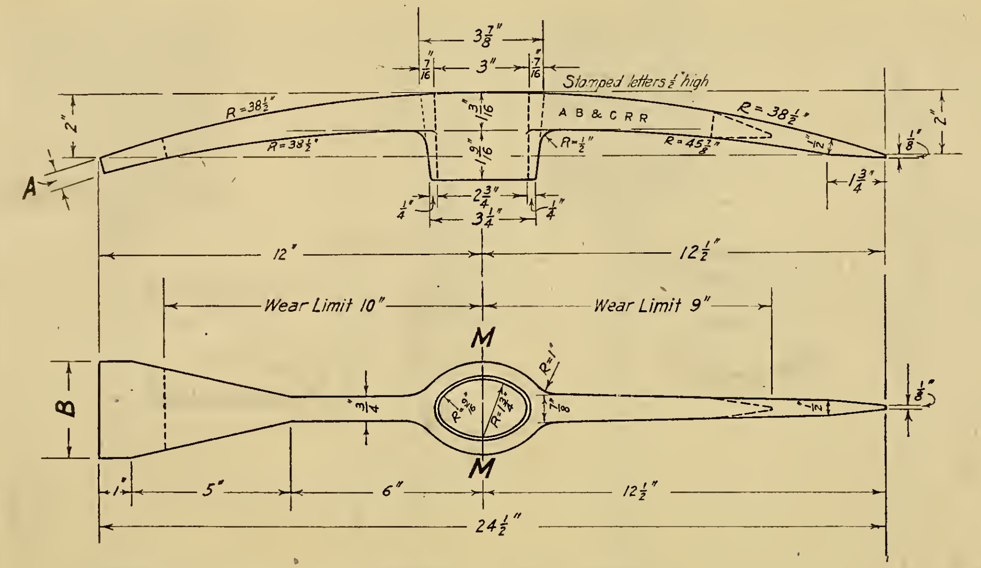
Thickness 0.0625"
U.S. Standard #16
Weight Approx 8 lbs.

FOURTEEN TINE BALLAST FORK

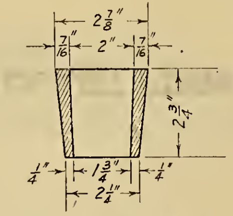


Thickness 0.0625"
U.S. Standard #16
Weight Approx. 7¾ lbs.

FIFTEEN TINE BALLAST FORK



Name of Manufacturer with month and year made to be stamped on pick



SECTION M-M

SIZE	A	B	WEIGHT
1	$\frac{1}{2}''$	$3''$	$7\frac{1}{2}$ lb.
2	$\frac{5}{8}''$	$3''$	$7\frac{2}{3}$ lb.
3	$\frac{3}{4}''$	$2\frac{1}{2}''$	$7\frac{7}{8}$ lb.

TAMPING PICKS

[14]USE AND LIMITATION OF MECHANICAL TOOLS.

Mechanical devices used to save labor and expense and to expedite the work fall naturally into sequence from the pit, quarry or ballast pile to the finished track.

Cars for transporting ballast should be carefully chosen with regard to the work to be done—whether it is to be on track already laid or for an additional parallel track.

If for raising track, hopper cars should be used with the ballast plow or tie drag. If for parallel track side dumps are to be preferred, especially when air operated. Convertible cars where the sides swing out and up, when used with the side plow and unloading engine-drum and cable, are fairly satisfactory when dump cars are not available, which is usually the case when stone ballast is furnished from a private quarry.

Anchoring the train and pulling the plow through the train by cable from the locomotive is a poor substitute for the unloading engine. It does beat unloading by hand.

The spreader car, especially when air operated, is effective and should be in general use. With this car, ballast for new second track work previously dumped alongside the running track from side dump cars or unloaded by side plows, can be spread out to a grade 2 in. below the bottom of tie and to the outside shoulder at a speed of eight miles per hour. When not in use on ballast work the spreader can be used on a grading dump, and in wet clay or rock, will do the work of fifty men and remain idle most of the time at that.

The mechanical tamper has passed the stage where its usefulness under favorable circumstances needs further defense.

Around terminals and yards where there is a large amount of frog and switch work, so far as this Committee knows there is no disposition to question the expediency of its use based on its merits alone, entirely apart from any question of scarcity of labor.

[15]CLEANING FOUL BALLAST.

Under usual conditions no ballast, except stone or hard slag, should be cleaned.

---

[14] Adopted, Vol. 22, 1921, pp. 83, 957.
[15] Adopted, Vol. 22, 1921, pp. 83, 957.

Ballast should be cleaned when foul enough to prevent proper drainage.

Clean with ballast forks or screens.

Clean shoulder down to sub-grade.

Clean crib to bottom of ties.

Clean space between tracks to depth of six (6) inches or more below the bottom of ties.

Clean the berm to bottom of ballast, preferably not less than twelve (12) inches below bottom of tie.

Clean cross ditches between ties approximately every rail length or thirty-three (33) feet. Cross ditches should not be under rail joints.

Return ballast when cleaned and apply sufficient new ballast to produce the standard section.

Tests, fully described in the report of the Committee on Ballast for 1914, indicate stone ballast can be cleaned by use of screens for approximately one-half cost of cleaning stone ballast with forks. (For diagram showing details of collapsible screens, see 1914 report.)

Stone ballast should be cleaned: In terminals, at intervals of one (1) to three (3) years. Heavy traffic, at intervals of three (3) to five (5) years. Light traffic lines, at intervals of five (5) to eight (8) years.

Per cent. of new stone ballast to be applied: Fifteen (15) to twenty-five (25) per cent.

[16]REINFORCEMENT UNDER BALLAST.

Concrete slabs placed under the ballast on soft roadbed where traffic is heavy, and at times under other exceptional circumstances, indicate that a considerable degree of success may be expected from their use, and at reasonable expense. (See Vol. 21, pp. 447 to 465.)

[17]BALLASTING BY CONTRACT.

The consensus of opinion is strongly against ballasting by contract in normal times and especially so on operated track.

Advocates of ballasting by contract do so largely as an emergency measure because of the greater flexibility of a contractor's organization in changing the rates of pay and so securing labor in times of stress.

---

[16] Adopted, Vol. 22, 1921, pp. 84, 957.
[17] Adopted, Vol. 22, 1921, pp. 84, 957.

COMMITTEE III.

TIES.

[1]DEFINITIONS.

All-Heart Tie.—A tie having no sapwood.

Boxed-Heart Tie.—An "all-heart" tie with the pith of the tree at or near the centers of the ends of the tie. (Known also as "rifle" or "target" tie.)

Composite Tie.—A tie the essential parts of which are composed of two or more materials.

Concrete Tie.—A tie the essential parts of which are composed of concrete, plain or reinforced.

Cull Tie.—A tie which does not conform to the specifications.

Doty Tie.—A tie affected with a fungous disease.

Half-Moon Tie.—A tie hewed or sawed on top and bottom only, but with bottom of markedly greater width than the top. (Known also as "half-round" tie). Also a tie hewed or sawed on bottom, top, and sides, with the pith of the tree at or near the bottom of the tie, about midway between the two sides. (Known also as "halved" tie.)

Half-Round Tie.—A tie hewed or sawed on top and bottom only, but with the bottom of markedly greater width than the top. (Known also as "half-moon" tie.)

Halved Tie.—A tie hewed or sawed on top, bottom, and sides, with the pith of the tree at or near the bottom of the tie, about midway between the two sides.

Head Block.—A tie or ties of a set used to support the switchpoint operating mechanism.

Heart Tie.—A tie with sapwood no wider than one-fourth the width of the top of the tie between 20 in. and 40 in. from the middle of the tie.

Heart-and-Back Tie.—A tie with the pith of the tree at or near the side of the tie, about midway between the top and the bottom of the tie. (Known also as "wing" tie.)

Intermediate Tie.—Any tie used between joint ties.

Joint Tie.—A tie used under a rail joint.

Pecky Tie.—A tie made from a cypress tree affected with a fungous disease, known locally as peck.

---

[1] Adopted, Vol. 5, 1904, pp. 73, 74, 78, 106-120, 131, 132; Vol. 6, 1905, pp. 766, 767; Vol. 7, 1906, pp. 33, 37, 66; Vol. 11, Part 2, 1910, pp. 863, 901; Vol. 16, 1915, pp. 522, 1089; Vol. 22, 1921, pp. 317, 1003.

Pole Tie.—A tie made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "round" tie; and may be "rifle" or "target" tie, "slabbed" tie, or "half-round" or "half-moon" tie.)

Quartered Tie.—A tie hewed or sawed on top, bottom, and sides, with the pith of the tree at or near a corner of the tie.

Rectangular Tie.—A tie hewed or sawed on top, bottom, and sides. (Known also as "pole" tie, "squared" tie, and "squared-pole" tie; and may be "rifle" or "target" tie, "half-moon" or "halved" tie, "heart-and-back" or "wing" tie, "boxed-heart" tie, or "quartered" tie.)

Rifle Tie.—A tie with the pith of the tree at or near the centers of the ends of the tie. (Known also as "target" tie and "boxed-heart" tie; and may be hewed or sawed on two or four longitudinal surfaces.)

Round Tie.—A tie with rounded sides made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "pole" tie; and may be "rifle" or "target" tie or "slabbed" tie.)

Sap Tie.—A tie with sapwood wider than one-fourth the width of the top of the tie between 20 in. and 40 in. from the middle of the tie.

Score Mark.—A mark made by the axe as an aid in hewing.

Slab Tie.—A tie made from the first or outside cut of a log.

Slabbed Tie.—A tie sawed on top and bottom only. (Known also as "pole" tie and "round" tie.)

Split Tie.—A tie riven out of a cross-section, which is generally of sufficient diameter to yield two or more ties.

Squared Tie.—A tie hewed or sawed on top, bottom, and sides. (Known also as "pole" tie, "squared-pole" tie, and "rectangular" tie; and may be "rifle" or "target" tie, "half-moon" or "halved" tie, "heart-and-back" or "wing" tie, "boxed-heart" tie, or "quartered" tie.

Squared-Pole Tie.—A tie hewed or sawed on top, bottom, and sides, made from a tree of such diameter that not more than one tie can be made from a cross-section. (Known also as "squared" tie; and may be "rifle" or "target" tie or "boxed-heart" tie.)

Steel Tie.—A tie the essential parts of which are composed of steel.

Substitute Tie.—Any tie other than a wood tie.

Switch Tie.—A tie of a set used to support a turnout.

Tapped Tie.—A tie made from a tree, the resin or turpentine of which has been extracted before felling.

Target Tie.—A tie with the pith of the tree at or near the centers of the ends of the tie. (Known also as "rifle" tie, and may be hewed or sawed on two or four longitudinal surfaces.)

Treated Tie.—A tie which has been subjected to a process designed to protect it from decay.

Triangular Tie.—A tie with three longitudinal surfaces, the widest of which is the top of the tie.

Wane Tie.—A squared tie showing part of the original surface of the tree on one or more corners.

Wing Tie.—A tie with the pith of the tree at or near the side of the tie, about midway between the top and bottom of the tie. (Known also as "heart-and-back" tie.)

[2]SPECIFICATION FOR CROSS-TIES.

Material.

***Kinds of Wood.**

Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for cross-ties will be accepted: Ash, Beech, Birch, Catalpa, Cedar, Cherry, Chestnut, Cypress, Elm, Fir, Gum, Hackberry, Hemlock, Hickory, Larch, Locust, Maple, Mulberry, Oak, Pine, Poplar, Redwood, Sassafras, Spruce, Sycamore, and Walnut. Others will not be accepted unless specially ordered.

---

*It is expected that each railroad will specify only the kind or kinds of wood it desires to use.

Physical Requirements.

General Quality.

All ties shall be free from any defects that may impair their strength or durability as cross-ties, such as decay, large splits, large shakes, large or numerous holes or knots, or grain with slant greater than one in fifteen.

Resistance to Wear.

Ties from needle-leaved woods shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have not less than one-third summerwood in six or more rings of annual growth, or not less than one-half summerwood in fewer rings. Ties of coarse wood having fewer rings or less summerwood will not be accepted unless specially ordered.

Resistance to Decay.

Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top of the tie between 20 inches and 40 inches from the middle, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

---

[2] Adopted, Vol. 5, 1904, pp. 72, 73, 78, 120-132; Vol. 6, 1905, pp. 763-766; Vol. 7, 1906, pp. 34-36, 65, 66; Vol. 17, 1916, pp. 243-245; Vol. 21, 1920, pp. 578, 1416-1423; Vol. 22, 1921, pp. 328, 1006.

DESIGN.

[*]Dimensions.

Before manufacturing ties, producers shall ascertain which of the following lengths, shapes, or sizes will be accepted, and whether ties are to be hewed or sawed and in either case whether on the sides as well as on the top and the bottom.

All ties shall be eight (8) feet, eight (8) feet six (6) inches, or nine (9) feet long.

All ties shall measure as follows throughout both sections between 20 inches and 40 inches from the middle of the tie:

Grade.	Sawed or Hewed Top, Bottom and Sides.	Sawed or Hewed Top and Bottom.
1	None accepted.	6" thick x 6" wide on top.
2	6" thick x 7" wide on top.	6" thick x 7" wide on top.
3	6" thick x 8" wide on top.	6" thick x 8" wide on top. 7" thick x 7" wide on top.[†]
4	7" thick x 8" wide on top.	7" thick x 8" wide on top.
5	7" thick x 9" wide on top.	7" thick x 9" wide on top.
6	7" thick x 10" wide on top.	7" thick x 10" wide on top.

MANUFACTURE.

All ties, except those of...,
(Insert kind or kinds of wood)
shall be made from trees which have been felled not longer than one month.

All ties shall be straight, well hewed or sawed, cut square at the ends, have bottom and top parallel, and have bark entirely removed.

INSPECTION.

Ties will be inspected after delivery at suitable and convenient places satisfactory to the railroad, which reserves the right to inspect ties at points of shipment or at destination. Ties will be inspected at points other than the railroad's property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector while away from rail or steamer lines and transport him from and to a railroad station or steamer landing.

---

[*] It is expected that each railroad will specify only the length or lengths, shape or shapes, and size or sizes it desires to use; but each railroad will use the standard designation for whatever size of tie it specifies. For example, a railroad desiring 6-in. x 8-in. ties only will designate them as Grade 3; a railroad desiring 7-in. x 9-in. ties only will designate them as Grade 5. A railroad shall not designate 6-in. x 8-in. ties as Grade 1 and 6-in. x 6-in. as Grade 2, or 7-in. x 9-in ties as Grade 1 and 7-in. x 8-in. as Grade 2. A railroad which desires to use ties less than 6 in. thick or 6 in. wide on top, or ties rejectable under the standard specification for other reasons, shall not give to such ties a standard designation (1 to 6), but shall designate them as Grade 0 or as "usable rejects."

[†] It is expected that railroads which specify both 6-in. x 8-in. and 7-in. x 7-in. ties manufactured on top and bottom only and which desire to separate the 6-in. from the 7-in. ties will designate the 7-in. x 7-in. as Grade 3A.

Inspectors will make a reasonably close examination of the top, bottom, sides, and ends of each tie. Each tie will be graded independently, without regard for the grading of others in the same lot. Rafted or boomed ties too muddied for ready examination will be rejected. Ties handled over hoists will be turned over as inspected.

Ties will be rejected when decayed in the slightest degree, except that the following will be allowed: in cedar, "pipe or stump rot" up to 1½ in. in diameter and 15 in. deep; in cypress, "peck" up to the limitations as to holes; and, in pine, "blue sap stain."

A large hole in woods other than cedar is one more than ½ in. in diameter and 3 in. deep within, or more than 1 in. in diameter and 3 in. deep outside the sections of the tie between 20 in. and 40 in. from its middle. Numerous holes are any number equalling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.

A large knot is one exceeding in width more than ¼ of the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the sections of the tie between 20 in. and 40 in. from its middle. Numerous knots are any number equalling a large knot in damaging effect.

A shake is a separation of one ring of annual growth from another. One which is not over 4 in. long or ¼ in. wide will be allowed.

A split is a break across annual rings. One which is not over 10 in. long will be allowed, provided a satisfactory anti-splitting device has been properly applied.

A tie will be considered straight: (1) When a straight line along the top from the middle of one end to the middle of the other end is entirely within the tie; (2) when a straight line along a side from the middle of one end to the middle of the other is everywhere more than 2 in. from the top and the bottom of the tie.

A tie is not well hewed or sawed when its surfaces are cut into with scoremarks more than ½ in. deep or when its surfaces are not even.

The top and bottom of a tie will be considered parallel if the difference in the thicknesses at the two sides or ends does not exceed one-half (½) in.; that is, one side may be seven and one-quarter (7¼) in. while the other is six and three-quarters (6¾) in. wide; or one end may be six and three-quarter (6¾) in. while the other is seven and one-quarter (7¼) in. thick.

The lengths, thicknesses, and widths specified are minimum dimensions. Ties over 1 in. and under 2 in. more in thickness than the maximum specified will be accepted as one grade below the largest tie specified. Those 2 in. to 3 in. more in thickness than the maximum specified will be accepted as two grades below the largest tie specified. Those over 3 in. more in thickness or width or over 2 in. more in length than the maximum specified will be rejected. Ties will be graded up by their smaller ends and graded down by their larger ends. The dimensions of the tie will not be averaged.

All thicknesses and widths apply to the sections of the tie between 20 inches and 40 inches from the middle of the tie. All determinations of width will be made on the top of the tie, which is the narrower of the horizontal surfaces.

DELIVERY.

All ties, except those of..,
(Insert kind or kinds of wood)
shall be delivered to the railroad within one month after being made.

Ties delivered on the premises of the railroad for inspection shall be stacked not less than ten (10) ft. from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the view of trainmen or of people approaching the railroad. Ties shall be stacked in alternate layers of two (2) and seven (7), the bottom layer to consist of two (2) ties kept at least 6 in. above the ground. The second layer shall consist of seven (7) ties laid crosswise of the first layer. When the ties are rectangular, the two outside ties of the layers of seven and the layers of two shall be laid on their sides. The ties in layers of two shall be laid at the extreme ends of the ties in the layers of seven. No stack may be more than twelve layers high, and there shall be five feet between stacks to facilitate inspection. Ties which have stood on their ends on the ground will be rejected.

Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked, and the number of ties of each kind of wood in the stack.

All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

CLASS U—TIES WHICH MAY BE USED UNTREATED.

Group Ua	*Group Ub*	*Group Uc*	*Group Ud*
"Heart" Black Locust	"Heart" Douglas Fir	"Heart" Cedars	"Heart" Catalpa
"Heart" White Oaks	"Heart" Pines	"Heart" Cypress	"Heart" Chestnut
"Heart" Black Walnut		"Heart" Redwood	"Heart" Red Mulberry
			"Heart" Sassafras

CLASS T—TIES WHICH SHOULD BE TREATED.

Group Ta	*Group Tb*	*Group Tc*	*Group Td*
Ashes	"Sap" Cedars	Beech	"Sap" Catalpa
Hickories	"Sap" Cypress	Cherries	"Sap" Chestnut
"Sap" Black Locust	"Sap" Douglas Fir	Birches	Elms
Honey Locust	Hemlocks	Gums	Hackberry
Red Oaks	Larches	Hard Maples	Soft Maples
"Sap" White Oaks	"Sap" Pines		"Sap" Mulberries
"Sap" Black Walnut	"Sap" Redwood		Poplars
			"Sap" Sassafras
			Spruces
			Sycamore
			White Walnut

SHIPMENT.

Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sizes if inspected before loading.

[3]SPECIFICATION FOR SWITCH-TIES.

MATERIAL.

***Kinds of Wood.**

Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for switch-ties will be acceptable: Ash, Beech, Birch, Cedar, Cherry, Chestnut, Cypress, Fir, Gum, Hemlock, Larch, Locust, Maple, Oak, Pine, and Redwood. Others will not be accepted unless specially ordered.

PHYSICAL REQUIREMENTS.

General Quality.

All ties shall be free from any defects that may impair their strength or durability as switch-ties, such as decay, large splits, large shakes, large or numerous holes or knots, or grain with slant greater than one in fifteen.

Resistance to Wear.

Ties from needle-leaved trees shall be of compact wood throughout the top fourth of the tie. where any inch of any radius from the pith shall have not less than one-third summerwood in six or more rings of annual growth, or not less than one-half summerwood in fewer rings. Ties of coarse wood having fewer rings or less summerwood will not be accepted unless specially ordered.

---

*It is expected that each railroad will specify only the kind or kinds of wood it desires to use.

[3] Adopted, Vol. 17, 1916, pp. 245-246; Vol. 22, 1921, pp. 332, 1006.

Resistance to Decay.

Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top between twelve (12) in. from each end of the tie, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

DESIGN.

***Dimensions.**

Before manufacturing ties, producers shall ascertain what sizes of ties will be acceptable and whether ties are to be hewed or sawed and in either case whether on the sides as well as the top and the bottom.

All ties shall be seven (7) in. thick.

Ties sawed or hewed on top, bottom, and sides shall be not less than nine (9) in. wide on top throughout the section between twelve (12) in. from each end of the tie. Ties sawed or hewed on top and bottom only shall be not less than seven (7) in. wide on top throughout the section between twelve (12) in. from each end of the tie.

Each tie shall be of a length specified below:

(Bill of Material.)

MANUFACTURE.

All ties, except those of....................................... ..,
(Insert kind or kinds of wood)
shall be made from trees which have been felled not longer than one month.

All ties shall be straight, well hewed or sawed, cut square at the ends, have bottom and top parallel, and have bark entirely removed.

INSPECTION.

Ties will be inspected after delivery at suitable and convenient places satisfactory to the railroad, which reserves the right to inspect ties at points of shipment or at destination. Ties will be inspected at places other than the railroad's property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shippers shall provide accommodations for the inspector while away from rail or steamer lines and transport him from and to a railroad station or steamer landing.

Inspectors will make a reasonably close examination of the top, bottom, sides, and ends of each tie. Each tie will be judged independently, without regard for the decisions on others in the same lot.

---

*It is expected that each railroad will specify only the shape or shapes and size or sizes it desires to use.

Ties will be rejected when decayed in the slightest degree, except that the following will be allowed: in cedar, "pipe or stump rot" up to 1½ in. in diameter and 15 in. deep; in cypress, "peck" up to the limitations as to holes; and, in pine, "blue sap stain."

A large hole in woods other than cedar is one more than ½ in. in diameter and 3 in. deep within, or more than 1 in. in diameter and 3 in. deep outside the section between 12 in. from each end of the tie. Numerous holes are any number equalling a large hole in damaging effect.

A large knot is one exceeding in width more than ¼ of the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the section between 12 in. from each end of the tie.

A shake is a separation of one ring of annual growth from another. One which is not over 4 in. long or ¼ in. wide will be allowed.

A split is a break across annual rings. One which is not over 10 in. long will be allowed, provided a satisfactory anti-splitting device has been properly applied.

A tie will be considered straight: (1) When a straight line along the top from the middle of one end to the middle of the other end is entirely within the tie; (2) when a straight line along a side from the middle of one end to the middle of the other end is everywhere more than 2 in. from the top and the bottom of the tie.

A tie is not well hewed or sawed when its surfaces are cut into with scoremarks more than ½ in. deep and when its surfaces are not even.

The lengths, thicknesses, and widths specified are minimum dimensions. Ties over 1 in. more in thickness, over 3 in. more in width, or over 2 in. more in length will be rejected.

The top and bottom of a tie will be considered parallel if the difference in the thickness at the two sides or ends does not exceed ½ in.; that is, one side may be 7¼ in. while the other is 6¾ in. wide; or one end may be 6¾ in. while the other is 7¼ in. thick.

All thicknesses and widths apply to the section of the tie between 12 in. from each end of the tie. All determinations of width will be made on the top of the tie, which is the narrower of the horizontal surfaces.

DELIVERY.

All ties, except those of...,
(Insert kind or kinds of wood)
shall be delivered to the railroad within one month after being made.

Ties delivered on the premises of the railroad shall be stacked not less than ten (10) ft. from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the views of trainmen or of people approaching the railroad. Ties shall be stacked at least 6 in. above the ground. No tie shall be unsupported for more than ten (10) feet of its length. The ties in each layer of ten (10) or more shall be not less than 1 in. apart, and such layers shall be separated by stacking strips at least 1 in. thick and not more than 4 in. wide. If ties are used to separate the layers of ten (10) or more, and they are rectangular, such strip ties shall be laid on their sides and the two (2) outside ties as near as possible to the extreme ends of the ties in the layers of ten (10) or more. No ties shall be permitted to overhang more than 2 ft. No stack of ties shall be wider than 10 ft.

Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked, and the number of ties of each kind of wood in the stack.

All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

Class U—Ties Which May Be Used Untreated.

Group Ua	*Group Ub*	*Group Uc*	*Group Ud*
"Heart" Black Locust "Heart" White Oaks	"Heart" Douglas Fir "Heart" Pines	"Heart" Cedars "Heart" Cypress "Heart" Redwood	"Heart" Chestnut

Class T—Ties Which Should Be Treated.

Group Ta	*Group Tb*	*Group Tc*	*Group Td*
Ashes "Sap" Black Locust Honey Locust Red Oaks "Sap" White Oaks	"Sap" Cedars "Sap" Cypress "Sap" Douglas Fir Hemlocks Larches "Sap" Pines "Sap" Redwood	Beech Birches Cherries Gums Hard Maples	"Sap" Chestnut Soft Maples

Shipment.

Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sets or lengths if inspected before loading.

[1]CONSERVATION OF TIMBER SUPPLY.

(1) The use of treated ties wherever practicable is recommended.

(2) Ties should be protected from failure against mechanical wear by means of tie plates.

---

[1] Adopted, Vol. 10, 1909, pp. 490, 493, 494, 521-528; Vol. 11, 1910, pp. 863, 901; Vol. 16, 1915, pp. 522, 1091; Vol. 21, 1920, pp. 579, 1115.

(3) Tie specifications should be so drawn and enforced that only such small ties as result from conservative methods of lumbering would be accepted, thus discouraging the cutting of small trees.

(4) Measures should be adopted for reducing forest fires.

(5) Owners should be encouraged to re-forest their lands either by re-planting or natural reproduction.

(6) Proper means should be used to aid in the investigation of tax laws pertaining to forest lands, to obtain legislation which would make it possible to hold growing timber for the purpose of future tie production.

(7) The species of trees to be grown should be selected only after careful and expert study of the available soils and climate.

(8) Plantations should be of such extent as to warrant maintenance appropriations sufficient to insure proper attention.

(9) Experiments with substitute ties should be encouraged.

[5]USE OF DATING NAILS.

(1) A dating nail should be driven in the upper side of every treated tie ten inches inside of the rail on the line side of the track. The tie should be laid with the end having the year stamped on it on the line side of the track. The dating nail should be driven the same day the tie is put in.

(2) Section Foremen should be especially careful to see that marks or nails intended to identify ties are not injured or destroyed.

(3) In addition to the use of the dating nail, each tie should be stamped with the year, at the treating plant, before treatment, and, preferably, should be stamped on both ends.

[6]SPECIFICATIONS FOR DATING NAILS.

Material.

1. The nail shall be made of iron or steel evenly and uniformly galvanized with a coating of zinc. It shall be ¼-inch in diameter, 2½ inches in length, with head ⅝-inch in diameter. Two figures designating the year, the figures to be ⅜-inch in length and depressed into the head 1/16-inch, shall be stamped therein.

Test.

2. Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry. This process shall be repeated. If after the fourth

---

[5] Adopted, Vol. 7, 1906, pp. 37, 67; Vol. 11, Part 2, 1910, pp. 863, 901.

[6] Adopted, Vol. 7, 1906, pp. 38, 67, 68; Vol. 11, Part 2, 1910, pp. 863, 901.

immersion there is a copper-colored deposit on the sample, or the zinc has been removed, the lot from which the sample was taken shall be rejected.

Chemicals.

3. The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystalized copper sulphate in 100 parts of water. This solution shall have a specific gravity of 1.185 at 70 degrees Fahrenheit, and the temperature shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit.

[7]TIE RENEWALS IN CONTINUOUS STRETCHES VERSUS SINGLE TIE RENEWALS.

The practice of single tie renewals is recommended.

[8]RECORDS OF CROSS-TIES.

Form M.W. 300

North & South Railroad.

FOREMAN'S MONTHLY TIE REMOVAL REPORT

Section No.................. Division................ Month of......................19....

Removed from Main Tracks					Removed from Side Tracks			
Number Removed	Year Put in	Kind of		Cause	Number Removed	Year Put in	Kind of	
		Timber	Treatment*				Timber	Treatment*

After approval by..........................it is to be forwarded to....................

....

Foreman.

This blank must be sent in monthly by all Foremen, whether any ties have been removed or not. When no ties have been removed, it must be so stated on the blank.

*Note.—When untreated ties are removed, make a dash (—) in "Treatment" column.

---

[7] Adopted, Vol. 13, 1912, pp. 342, 959.
[8] Adopted, Vol. 3, 1902, pp. 102-105, 109-113; Vol. 21, pp. 590, 1415-1416.

Form M. W. 301

North and South Railroad.

SUMMARY OF TIES USED IN RENEWALS DURING THE YEAR 19—.

Main Tracks...

Side Tracks...

Total Mileage...

Kind of Wood	Treated or Untreated	Main Tracks	Side Tracks	Total Track	
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
Total	....	....	....	....	....

[9]ECONOMIC COMPARISON OF CROSS-TIES OF DIFFERENT MATERIALS.

Except in isolated cases, ultimate economy in labor and material results from the use of properly treated ties, as compared with untreated ties.

The economy of any tie of known price and life may be determined by the following formulas:

Given:

$C =$ First cost of tie.

$C^1 =$ Amount of compound interest which will produce interest equalling first cost of tie, during life of tie.

$R =$ Rate of interest.

$n =$ Life of tie in years.

Required—Total capitalization of tie:

$$= C + C^1 = \frac{C(1+R)^n}{(1+R)^n - 1} \quad \text{.............................} (1)$$

---

[9]Adopted, Vol. 16, 1915, pp. 521, 1091.

Given:

C = First cost of tie.
R = Rate of interest.
I = Interest on first cost.
A = Amount at compound interest which will provide for renewal at end of life of tie.
n = Life of tie in years.

Required—Total annual cost:

$$I = CR$$

$$A = \frac{CR}{(1 + R)^n - 1}$$

Total annual cost =

$$I + A = \frac{CR\,(1 + R)^n}{(1 + R)^n - 1} \quad \ldots\ldots (2)$$

Given:

R = Rate of interest.
C = Cost of tie of n years life.
C^1 = Cost of tie of n^1 years life.

Tie costs are equivalent when the capitalization or annual costs are equal, or—

$$C^1 = \frac{C(1 + R)^n}{(1+R)^n - 1} \times \frac{(1+R)^{n^1} - 1}{(1+R)^{n^1}} \quad \ldots\ldots (3)$$

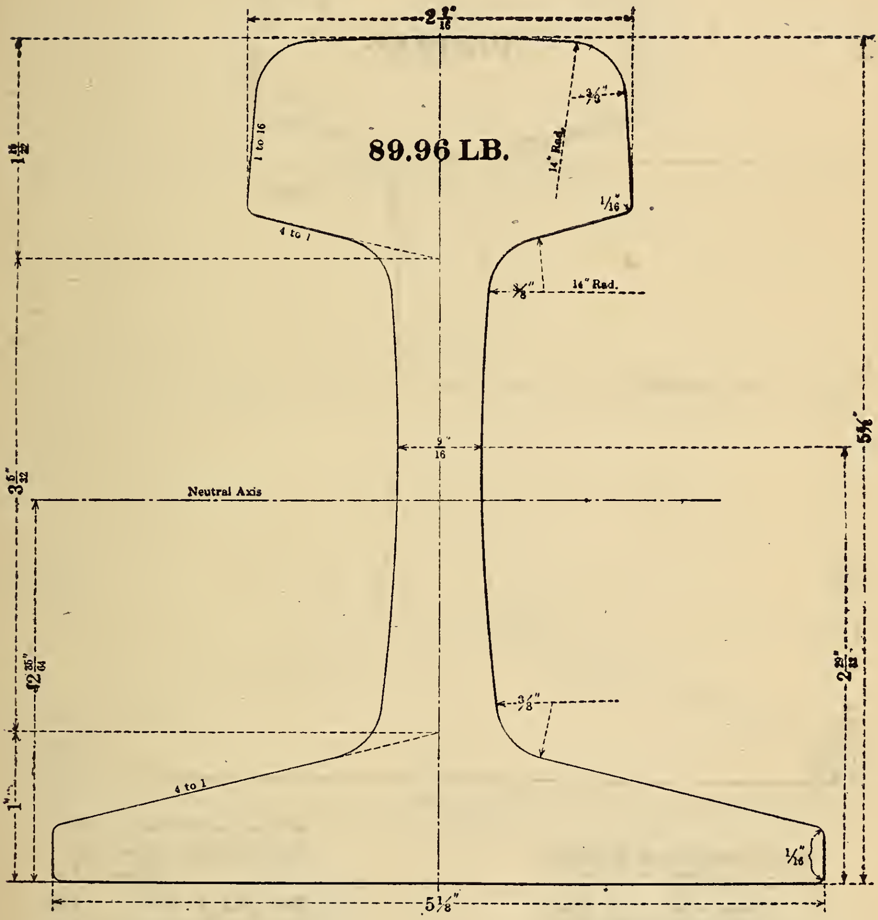
COMMITTEE IV.

RAIL.

---

[1]STANDARD RAIL SECTIONS

RAIL SECTION—R. A.-A.—90-LB.



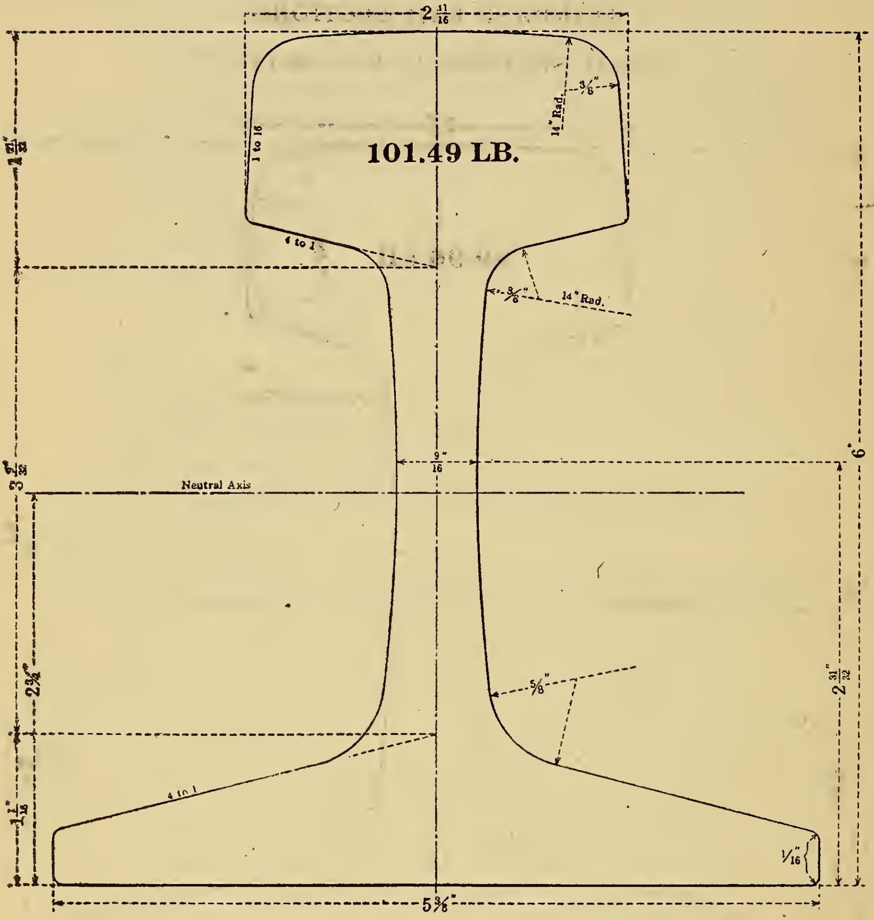
Area: Head=3.20	sq.	in.	36.2%
Web =2.12	"	"	24.0%
Base =3.50	"	"	39.8%
Total =8.82	"	"	100.0%

Moment of Inertia	38.7
Section Modulus, Head	12.56
" " Base	15.23
Ratio M.I. to Area	4.39
Ratio Sec. Mod. to Area	1.42

---

[1] Adopted, Vol. 16, 1915, pp. 397, 1117.

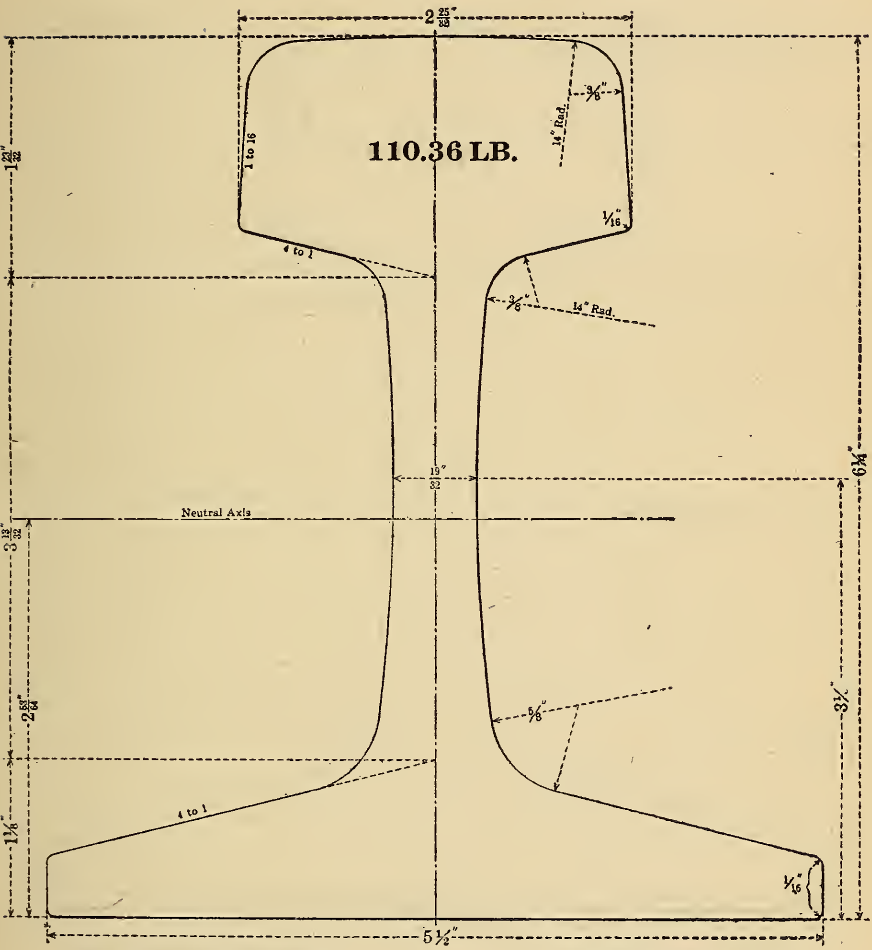
RAIL SECTION—R. E.—100-LB.



Area:			
Head	=3.80	sq. in.	38.2%
Web	=2.25	" "	22.6%
Base	=3.90	" "	39.2%
Total	=9.95	" "	100.0%

Moment of Inertia	49.0
Section Modulus, Head	15.1
" " Base	17.8
Ratio M.I. to Area	4.92
Ratio Sec. Mod. to Area	1.52

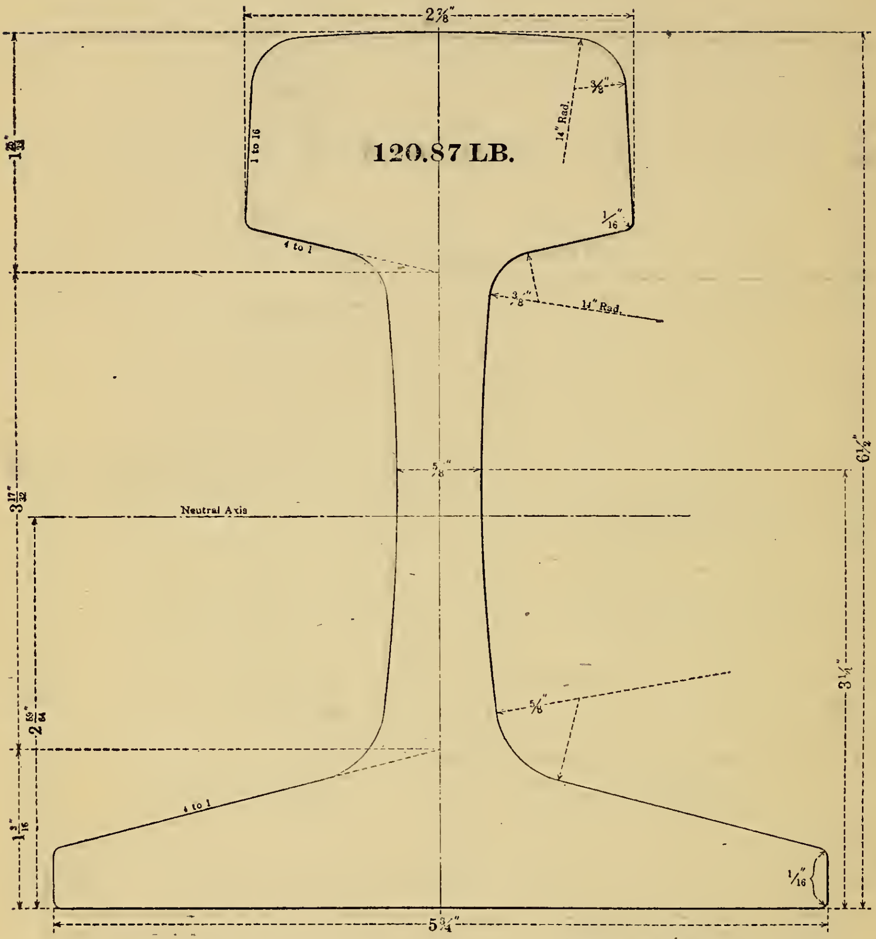
RAIL SECTION—R. E.—110-LB.



Area: Head = 4.04 sq. in. 37.4%
Web = 2.49 " " 23.0%
Base = 4.29 " " 39.6%
Total = 10.82 " " 100.0%

Moment of Inertia	57.0
Section Modulus, Head	16.7
" " Base	20.1
Ratio M.I. to Area	5.27
Ratio Sec. Mod. to Area	1.55

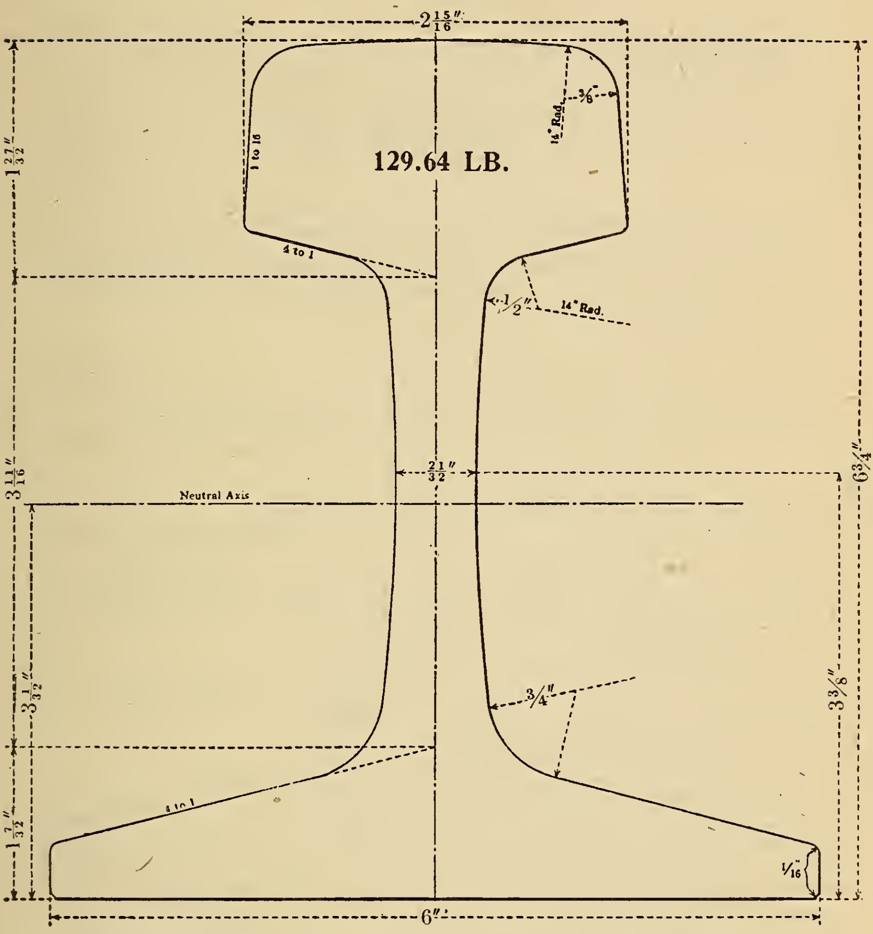
RAIL SECTION—R. E.—120-LB.



Area:			
Head	=4.40	sq. in.	37.1%
Web	=2.69	" "	22.7%
Base	=4.76	" "	40.2%
Total	=11.85	" "	100.0%

Moment of Inertia	67.6
Section Modulus, Head	18.9
" " Base	23.1
Ratio M.I. to Area	5.71
Ratio Sec. Mod. to Area	1.59

[2]RAIL SECTION—R. E.—130-LB.



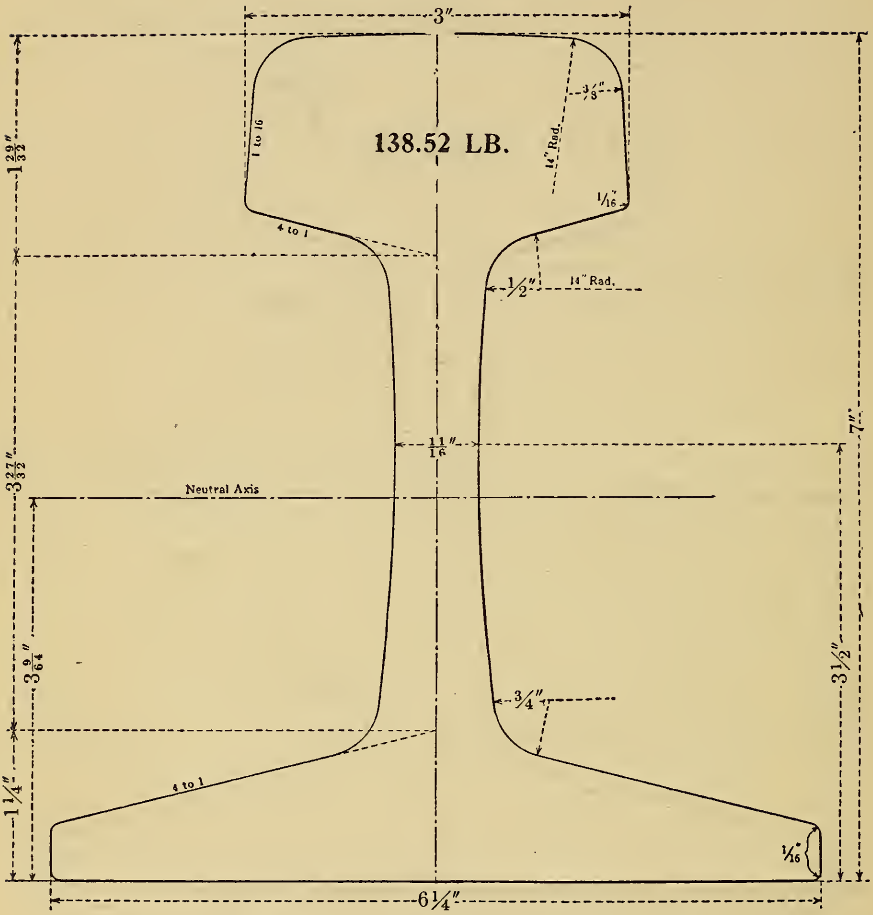
Area: Head	=4.63	sq. in.	36.4%
Web	=3.02	"	" 23.8%
Base	=5.06	"	" 39.8%
Total	=12.71	"	" 100.0%

Moment of Inertia	77.4
Section Modulus, Head	20.8
" " Base	25.6
Ratio M. I. to Area	6.09
Ratio Sec. Mod. to Area	1.64

---

[2]Adopted, Vol. 21, 1920, p. 1455.

RAIL SECTION—R. E.—140-LB.



Area:	Head	=4.93 sq. in.	36.3%
	Web	=3.28 " "	24.1%
	Base	=5.37 " "	39.6%
	Total	=13,58 " "	100.0%

Moment of Inertia	89.2
Section Modulus, Head	23.1
" " Base	28.4
Ratio M.I. to Area	6.56
Ratio Sec. Mod. to Area	1.70

[2]SPECIFICATIONS FOR CARBON STEEL RAILS—1920.

(I) INSPECTION.

Access to Works.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the rails have been made and loaded in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspections shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

(II) MATERIAL.

Material.

3. The material shall be steel made by the Bessemer or Open-Hearth process, as provided by the contract.

(III) CHEMICAL REQUIREMENTS.

Chemical Composition.

4. The chemical composition of the steel, determined as prescribed in Section 6, shall be within the following limits:

Constituent Elements	Bessemer Process (Limits per cent.)		Open-Hearth Process (Limits per cent.)		
	Weight in lb. per yard		Weight in lb. per yard		
	70-84	85 and over	70-84	85-110	111 & over
Carbon	0.40 to 0.50	0.45 to 0.55	0.53 to 0.68	0.62 to 0.77	0.67 to 0.82
Phosphorus, not to exceed	0.10	0.10	0.04	0.04	0.04
Manganese	0.80 to 1.10	0.80 to 1.10	0.60 to 0.90	0.60 to 0.90	0.60 to 0.90
Silicon, not less than	0.10	0.10	0.10	0.10	0.10

Average Carbon.

5. It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

Analyses.

6. In order to ascertain whether the chemical composition is in accordance with the requirements, analyses shall be furnished as follows:

---

[2]Adopted, Vol. 3, 1902, pp. 204, 208; Vol. 5, 1904, pp. 465, 469; Vol. 6, 1905, p. 190; Vol. 7, 1906, pp. 549, 552, 559, 562, 573, 576; Vol. 10, Part 1, 1909, pp. 374, 393; Vol. 11, Part 1, 1910, pp. 237, 252, 255; Vol. 12, Part 1, 1911, p. 467; Vol. 12, Part 2, 1911, p. 12; Vol. 13, 1912, pp. 853, 1017; Vol. 14, 1913, pp. 181, 1103; Vol. 15, 1914, pp. 158, 375, 1104; Vol. 16, 1915, pp. 157, 159, 1117; Vol. 21, 1920, pp. 1070, 1455.

(A) *Bessemer Process.*—The manufacturer shall furnish to the inspector, daily, carbon determination for each heat before the rails are shipped, and two chemical analyses every twenty-four hours representing the average of the elements, carbon, manganese, silicon, phosphorus and sulphur contained in the steel, one for each day and night turn, respectively. These analyses shall be made on drillings taken from the ladle test ingot not less than one-eighth inch beneath the surface.

(B) *Open-Hearth Process.*—(a) Finished Rail Analysis. On each heat the manufacturer shall make an analysis of the elements, carbon, manganese, phosphorus, sulphur and silicon. A copy of the results shall be given to the inspector. Drillings for these analyses shall be taken longitudinally of the rail with a ½-inch drill, close to an upper corner of the head from any one of the three drop test pieces representing the top of the ingot, or from pieces cut adjacent to any one of these three drop test pieces.

(b) *Ladle Analyses.*—For the information of the inspector the manufacturer shall furnish a chemical analysis of the elements, carbon, manganese, silicon, phosphorus and sulphur, for each heat. These analyses shall be made on drillings taken from the ladle test ingots not less than ⅛-inch beneath the surface.

(C) *Check Analysis.*—On request of the inspector, the manufacturer shall furnish a portion of the ladle test ingot for the Bessemer process and a portion of the drillings from the finished rail for the Open-Hearth process for check analysis. When made a part of the contract, the manufacturer shall furnish the necessary facilities at the mill for the purchaser's representative to make the check analysis.

(D) When the analyses for carbon by the mill chemists and by the railroad chemist do not agree, a tolerance of two points below the minimum and two points above the maximum will be allowed to cover such variation before condemnation.

(IV) PHYSICAL REQUIREMENTS.

Physical Qualities.

7. Tests shall be made to determine:
   (a) Ductility or toughness as opposed to brittleness;
   (b) Soundness.

Method of Testing.

8. The physical qualities shall be determined by:
   (a) The Drop Test, or
   (b) The Quick Bend Test, if made a part of the contract.

Drop Testing Machine.

9. The drop testing machine used shall be the standard of the American Railway Engineering Association, the essential points of which are:

(a) The tup shall weigh 2000 lb., and have a striking face with a radius of five inches.

(b) The anvil block shall weigh 20,000 lb., and be supported on springs.

(c) The supports for the test pieces shall be a part of, and firmly secured to, the anvil; their bearing surfaces shall have a radius of five inches.

(d) The spacing of the supports between centers shall be: 3 feet for rails weighing 110 lb. or less per yard; 4 feet for rails weighing from 111 to 140 lb. per yard, inclusive.

Machine for Quick Bend Test.

10. The quick bend test shall be made with an hydraulic press of not less than 350 tons capacity, some of the details of which are as follows:

(a) The foundations for the supports of the test specimens shall be adequate to sustain rigidly the total load applied by the press.

(b) The supports shall be solid flat bearing surfaces with vertical faces 48 inches apart, with the inner edges rounded to a ⅛-inch radius.

(c) The head of the ram shall have a bearing face with a radius of five inches.

(d) The speed of the ram shall approximate 13 feet per minute when allowed free travel.

(e) An hydraulic indicator shall be connected with the press so that the pressure on the head of the ram is registered by the pen arm on a vertical scale, and the distance rotated by the cylinder shall be proportional to the travel of the ram head.

Test Specimens.

11. (a) Test specimens shall be one or two feet longer than the span between supports in the testing machine.

(b) Test specimens shall be cut from the crop of the top rail of the ingot, and marked on the center line of the top surface of the head with gage marks one inch apart for three inches each side of the center of the specimen, for measuring the ductility of the metal.

(c) Where it is necessary to test rails lower than the first rail, the bottom of the first rail, in lieu of the top of the second rail, and the bottom of the second rail, in lieu of the top of the third rail, will be accepted, if preferred by the manufacturer.

(d) The temperature of the test specimens shall be between 60 and 100 degrees Fahrenheit.

(e) Unless otherwise instructed by purchaser, the test specimens shall be tested with head in tension and with the center punch marks midway between supports.

Height of Drop.

12. The test piece shall be subjected to impact of the tup falling free from the following heights:

For 70 to 79 lb. rail, incl.	16 feet
For 80 to 90 lb. rail, incl.	17 feet
For 91 to 110 lb. rail, incl.	18 feet
For 111 to 140 lb. rail, incl.	20 feet

Elongation.

13. Under these impacts the rail under one or more blows shall show at least 8 per cent. elongation for one inch of the six-inch scale, marked as described in Section 11 (b).

Exhausted Ductility Test.

14. A sufficient number of blows shall be given to determine the complete elongation of the test piece of at least every fifth heat of Bessemer steel, and of one out of every three test pieces of a heat of Open-Hearth steel.

Permanent Set.

15. For each specimen, a record shall be made of the permanent set, measured on a 3 ft. chord, after each blow under the drop test.

Test to Destruction.

16. The test pieces which do not break under the first or subsequent blows shall be nicked and broken, to determine whether the interior metal is sound. The words "interior defect," used below, shall be interpreted to mean seams, laminations, cavities or interposed foreign matter made visible by the destruction tests, the saws or the drills.

Bessemer Process Physical Tests.

17. One piece shall be tested from each heat of Bessemer steel.

(a) If the test piece shows the required elongation (Section 13), all the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(b) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) A second test shall then be made of a test piece selected by the inspector from the top end of any second rail of the same heat, preferably of the same ingot. If the test piece shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(d) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the second rails from that heat shall be rejected.

(e) A third test shall then be made of a test piece selected by the inspector from the top end of any third rail of the same heat, preferably of the same ingot. If the test piece shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect,

(f) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the remainder of the rails from that heat shall be rejected.

Open-Hearth Process Physical Tests.

18. Test pieces shall be selected from the second, middle and last full ingot of each Open-Hearth heat.

(a) If all of these test pieces show the required elongation (Section 13), all of the rails of the heat shall be accepted, provided that no test piece when broken shows interior defect.

(b) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) Second tests shall then be made from three test pieces selected by the inspector from the top end of any second rails of the same heat, preferably of the same ingots. If all these test pieces show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that no test piece when broken shows interior defect.

(d) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the second rails of the heat shall be rejected.

(e) Third tests shall then be made from three test pieces selected by the inspector from the top end of any third rails of the same heat, preferably of the same ingots. If all these test pieces show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that no test piece when broken shows interior defect.

(f) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the remainder of the rails from the heat shall be rejected.

No. 1 Rails.

19. "No. 1 Rails" shall be free from injurious defects and flaws of all kinds.

No. 2 Rails.

20. Rails which vary from the specifications in a manner which does not impair their soundness and strength will be accepted as "No. 2 Rails." The rails to be so accepted are as follows:

(a) Rails arriving at the straightening presses with sharp kinks or greater camber than that indicated by a middle ordinate of 4 inches in 33 feet for the thick base sections, and 5 inches for the thin base sections.

(b) Rails which do not contain surface imperfections in such number or of such character as will, in the judgment of the inspector, render them unfit for recognized No. 2 uses.

Rails accepted as No. 2 rails shall have the ends painted white, and shall have two prick punch marks on the side of the web near the heat number, near the end of the rail, so placed as not to be covered by the joint bars.

No. 2 rails to the extent of five per cent. of the entire order will be accepted.

(V) DETAILS OF MANUFACTURE.

Quality of Manufacture.

21. The entire process of manufacture shall be in accordance with the best current state of the art.

Record of Manufacture.

22. When made a part of the contract, the manufacturer shall furnish the inspector with a carbon copy of Open-Hearth or Bessemer charge sheets; records of melting, tapping, ladle and teeming conditions; soaking pit charge sheets, rolling mill operation; rail weight sheets; hot bed and straightening records, wherever such sheets or records are in regular use by the manufacturer.

Bled Ingots.

23. Bled ingots, from the center of which the liquid steel has been permitted to escape, shall not be used.

Discard.

24. There shall be sheared from the end of the bloom, formed from the top of the ingot, sufficient metal to secure sound rails.

Lengths.

25. The standard length of rails shall be 33 feet, at a temperature of 60 degrees Fahrenheit. Ten per cent. of the entire order will be accepted in shorter lengths varying by 1 foot from 32 to 25 feet. A variation of ¼-inch from the specified lengths will be allowed, excepting that for 15 per cent. of the order a variation of ⅜-inch from the specified lengths will be allowed. No. 1 rails less than 33 feet shall be painted green on both ends.

Stool Cutting.

26. Care should be taken in teeming the ingots to prevent cutting out of the cast iron of the stools of ingot molds by the falling stream of hot metal from the ladle, and thus avoid a frequent cause of carbon streaks found in the finished rail.

Mold Spattering.

27. Spattering the interior sides of the molds in pricking the heats or melts and teeming the ingots shall be avoided as much as possible.

Stopper Defects.

28. Excessive use of material thrown into the teeming ladle to set the stopper shall be avoided.

Aluminum.

29. The steel shall be made to set quiet by the chemical composition in the molds without the addition of aluminum, either in the ladle or molds.

Time for Ingot Setting.

30. Time shall be allowed for the tops of the ingots to set without spraying with water.

Ingots Vertical.

31. Ingots shall be kept in a vertical position on the ingot cars and in the reheating furnaces until their heat is equalized ready to be rolled.

Section.

32. The section of rails shall conform as accurately as possible to the template furnished by the Railway Company. A variation in height

of one-sixty-fourth inch less or one-thirty-second inch greater than the specified height and one-sixteenth inch in width of flange will be permitted; but no variation shall be allowed in the dimensions affecting the fit of the joint bars.

Weight.

33. The weight of the rails specified in the order shall be maintained as nearly as possible, after complying with the preceding Section. A variation of one-half of one per cent. from the calculated weight of section, as applied to the entire order, will be allowed.

Hot-Bed Work and Straightening.

34. (a) Care shall be taken in cambering the rails and with the hot-bed work so that rails will cool with a small but uniform sweep, and therefore gagging under the presses reduced to a minimum.

(b) Rails while on the cooling beds shall be protected from snow, water and excessive gusts of cold wind.

(c) When delivered to the straightening presses rails shall not vary in any direction from a straight line throughout their entire length more than 4 inches for the "RE" and "RA" thick base sections, and not more than 5 inches for "ASCE" sections.

(d) The supports for rails in the straightening presses shall have flat surfaces and be out of wind, and shall be spaced not less than 42 inches. The application of the gag shall be central between supports, and the overhang of either end of the rail during straightening should be supported.

(e) Rails heard to snap while being straightened shall be at once rejected.

Drilling.

35. Circular holes for joint bolts shall be drilled to conform to the drawings and dimensions furnished by the Railway Company. A variation of 1/32 inch in the size and location of bolt holes will be allowed.

Finishing.

36. (a) All rails shall be smooth at the heads, straight in line and surface, and without any twists, waves or kinks. They shall be sawed square at the ends, a variation of not more than one-thirty-second inch being allowed; and burrs shall be carefully removed.

(b) Rails improperly drilled or straightened, or from which the burrs have not been removed, shall be rejected, but may be accepted after being properly finished.

(c) When any finished rail shows interior defects at either end or in any drilled hole, the entire rail shall be rejected.

Branding.

37. Rails shall be branded for identification in the following manner:

(a) The name of the manufacturer, the month and year of manufacture, and the weight and type of section of rail shall be rolled in raised letters and figures on one side of the web. The type shall be marked by letters which signify the name by which it is known, as for example:

Sections of American Society of Civil Engineers............A. S. C. E.
Sections of American Railway Association.............R. A.-A., R. A.-B.
Sections of American Railway Engineering Association............R. E.

(b) The heat and ingot number as rolled and letter indicating the portion of the ingot from which the rail was made shall be plainly stamped on the web of each rail where it will not be covered by the joint bars. The top rails shall be lettered "A," and the succeeding ones "B," "C," "D," etc., consecutively; but in case of a top discard of from 20 to 35 per cent. the letter "A" will be omitted, the top rail becoming "B." If the top discard be greater than 35 per cent., the letter "B" shall be omitted, the top rail becoming "C."

(c) Open-Hearth rails shall be branded or stamped "O-H" in addition to other marks.

(d) All markings of rails shall be done so effectively that the marks may be read as long as the rails are in service.

Separate Classes.

38. All classes of rails shall be kept separate from each other.

Loading.

39. Rails shall be carefully handled and loaded in such manner as not to injure them. When a part of the contract, all first quality rails of each heat shall be kept together in loading.

Payment.

40. Rails accepted will be paid for according to actual weight.

Matters Subject to Contract.

Clause 3 —Steel may be Bessemer or Open-Hearth.
Clause 6c—Check analysis.
Facilities for analyses at the mill.
Clause 8b—The quick bend test.
Clause 22 —Record of manufacture.
Clause 40 —Loading.
Keeping rails of each heat together.

Notes on Manufacture Added as Information

(To Be Attached to the Specifications)

Note A:

The selection of the ores, scrap, molten metal, fluxes and other furnace additions; regulation and quality of the port gases; condition of the slag, furnace bottom and lining; temperature of the bath, and time for refinement of each melt of steel require especial attention so that the molten steel when tapped will be refined and deoxidized.

Note B:

The steel must be well deoxidized and the waste products eliminated before the ingots are teemed, and thus prevent minute portions of the deoxidation products from becoming entrained in the setting metal. Time is required for the deoxidation products and impurities to rise after the steel is tapped into the ladle.

Note C:

Loose material and dirt should be removed from the ladle before tapping is commenced to prevent impurities from being incorporated in the molten metal. The ladle lining should be well set before tapping.

Attention should also be given to the proper coating of the ingot molds, and care should be taken to remove dirt or loose material from the tops of the ingot buggies before setting up the molds.

Note D:

The ingots should be stripped as soon as the metal caps over on top; weighed and charged promptly into the soaking pits, and thus avoid cooling of the interior metal. This checks the shrinkage of the steel, which may be large, depending upon the volume, chemical composition and temperature of the ingot at the time it is charged. The interior shrinkage can be confined to 0.05 to 0.1 per cent. per cubic foot of the metal, so that it is eliminated in the usual discard of the bloom, and helps to prevent piped rails due to cold ingots.

Note E:

The ingots should be uniformly heated in the soaking pits and the port gases properly regulated to prevent overheating, and with protection from direct impingement against the vertical faces of the ingots. The large hot ingots should be soaked at least two hours before blooming.

Note F:

Blooming the ingots and rolling the blooms into finished rails should all be done when the ranges of temperature for the ingots, blooms and rails are suitable for the metal to be cambered and then cooled so that the transformations and recalescence will be complete for the desired steel.

Note G:

The hot rails from the saws and on the "hot-beds" should be spaced to allow the recalescence of the head to follow that of the base without being locked or blocked by adjacent rails on either side.

Note H:

The effect of straightening may be materially reduced for the heavier and stiffer sections by spacing the supports in the press at 60-inch centers.

Care should be taken to see that the supports of the presses are not worn hollow, and the gags used have rounded corners, and are in good condition.

[3]DRILLING OF RAILS.

(1) The distance of bolt holes above the base of the rail shall be such that the center line of the bolt holes shall be in the horizontal plane midway between the intersections of the vertical center line of the rail with the planes of the fishing surfaces of the head and base.

(2) The end clearance between adjacent rails, bolted in normal position, shall be ⅛-inch.

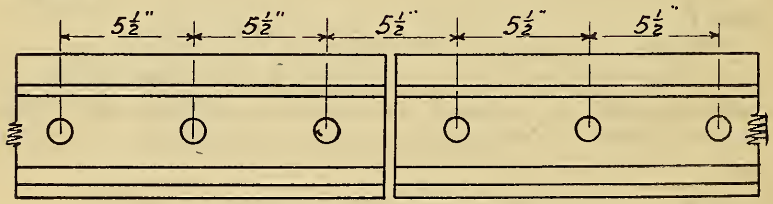
(3) For standard rails up to 120 lb. per yd., a one-inch bolt and a 1-1/16-inch bolt hole shall be used.

(4) For standard rails 120 lb. per yd. and over a 1-⅛-inch bolt and a 1-3/16-inch bolt hole shall be used.

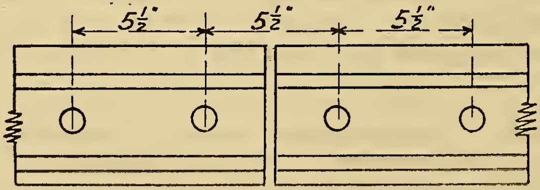
Application of Recommended Rail Drilling to Standard Rail Sections

Weight of Rail, Lbs.	*Type of Rail.*	*Height of Bolt Hole Above Base of Rail, Inches.*
90	RA-A	2 37/64
90	RA-B	2 11/32
100	RE	2 45/64
100	RA-A	2 3/4
100	RA-B	2 33/64
110	RE	2 53/64
120	RE	2 61/64
130	RE	3 1/16
140	RE	3 3/64

The standard drilling for rails should be as shown in the following diagrams:



RECOMMENDED 6-HOLE DRILLING.



RECOMMENDED 4-HOLE DRILLING.

---

[3] Adopted, Vol. 15, 1914, pp. 157, 1110; Vol. 21, 1920, pp. 1069, 1447.

[*]SPECIFICATIONS FOR DROP TEST MACHINE.

A drop test machine conforming essentially to the manufacturers' plans and specifications and in general accord with the following requirements will give satisfactory results:

1. The machine shall be arranged to allow a 2000-lb. tup to fall freely at least 25 feet on the center of a rail resting on supports that can be adjusted to spans varying from 3 feet to 4 feet 6 inches.

2. The anvil shall be a solid casting, weighing, with the attachments that move with it, 20,000 lbs. It shall be free to move vertically independent of the lead columns. It shall be supported on 20 springs known as the standard "C" spring, without center coil, as employed by the Master Car Builders' Association (their Fig. 5614). This spring has a free length of eight and one-quarter (8¼) inches, an outside diameter of five and seven-sixteenths ($5\frac{7}{16}$) inches, and is made from a bar having a diameter of one and three-sixteenths ($1\frac{3}{16}$) inches. These springs shall be arranged in groups of five at each corner of the anvil. They shall be held in place by hubs raised on the top of the base plate, and by circular pockets on the underside of the anvil. The anvil shall be guided in its vertical movement by removable finished wearing strips. These wearing strips shall be suitably attached to the finished edges of the column base.

3. The base-plate shall be of cast-iron or cast steel eight (8) inches thick in the area covered by the anvil. It shall be firmly secured to the substructure by four bolts two (2) inches in diameter.

4. The substructure shall consist of a timber grillage resting on a masonry foundation. The grillage shall project nine (9) inches beyond the ends of the base plate, and clear the columns at the side. It shall consist of one course of twelve by twelve (12 by 12) inches sound oak or Southern yellow pine, preferably creosoted, laid close and well bolted together. The masonry, preferably concrete, shall be not less than five (5) feet deep below the grillage, suitably supported on the subsoil.

5. The pedestals for supporting the test rail shall be substantial castings. The surface of the anvil between these pedestals shall be formed to receive a wooden block to absorb shock under broken test pieces. The rail supports shall be removable pieces of steel, securely held in the pedestals, having an upper cylindrical bearing surface, with

---

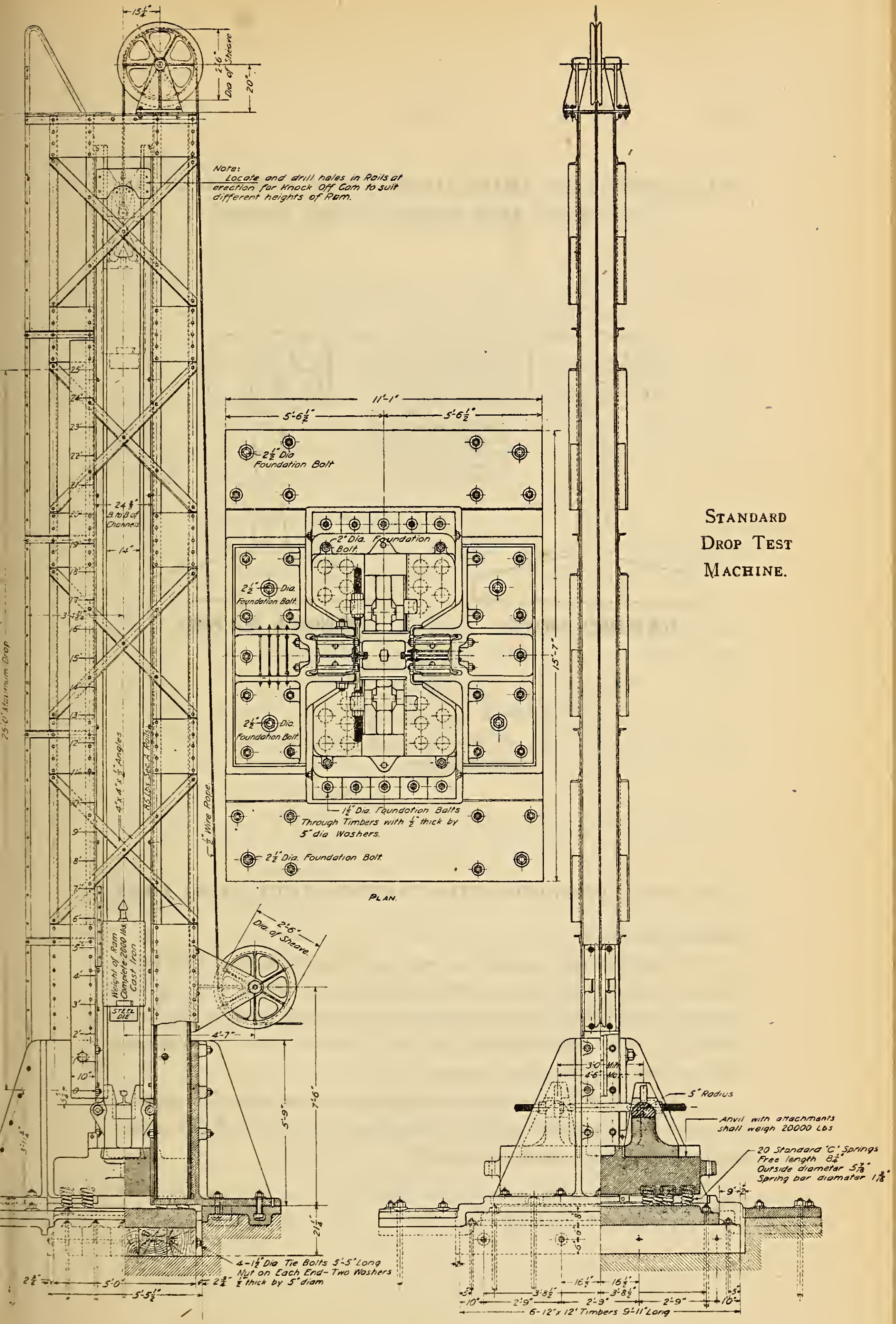
[*] Adopted, Vol. 10, Part 1, 1909, pp. 369-373, 375, 395, 396; Vol. 11, Part 1, 1910, pp. 240, 252, 562.

a radius of five (5) inches. The pedestals shall be adjustable to spans varying from three (3) feet minimum to four (4) feet six (6) inches maximum between centers. They shall be securely held together, and so fixed to the anvil as to insure that the center of the span shall always coincide with the center between leads.

6. The leads shall be firmly connected to the column base and well braced. They shall be long enough to provide the prescribed free fall of the tup. They shall be provided with a convenient ladder and a plainly marked gage, divided into one-foot intervals. The zero of this gage shall be five and one-quarter (5¼) inches above the top of the rail support. The specified height of drop shall be measured from this zero irrespective of the height of the rail being tested. One of the guides shall have a removable section six (6) feet long at the bottom, so that the tup or tripping block may be readily removed.

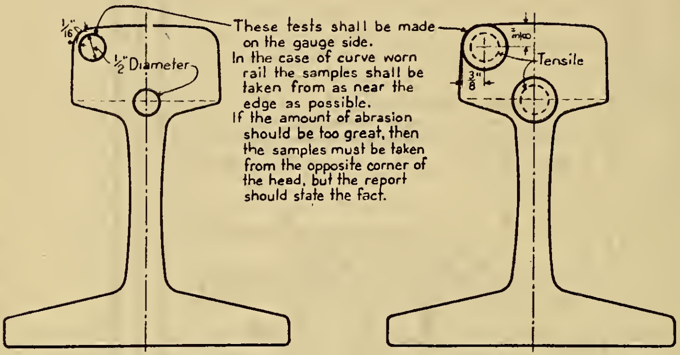
7. The tup shall weigh, with the accessories that drop with it, 2000 lbs. The striking die shall be of steel, having a cylindrical striking face, with a radius five (5) inches and a length of twelve (12) inches. The guide grooves shall have finished surfaces. The tripping head shall allow a grip of the tongs that will release at the exact height for which the tripping device is set, and that will be safe from accidental release while the test piece is being shifted.

8. The tongs and tripping device shall be arranged to release the tup automatically only. No manual releasing will be allowed. The tripping device shall be easily adjusted at one-foot intervals.



STANDARD
DROP TEST
MACHINE.

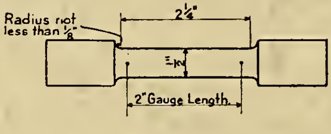
[5] STANDARD LOCATIONS OF BORINGS FOR CHEMICAL ANALYSES AND TENSILE TEST PIECES.



These tests shall be made on the gauge side. In the case of curve worn rail the samples shall be taken from as near the edge as possible. If the amount of abrasion should be too great, then the samples must be taken from the opposite corner of the head, but the report should state the fact.

FOR CHEMICAL ANALYSES

FOR PHYSICAL TEST PIECES



[6] SPECIFICATIONS FOR HIGH-CARBON STEEL JOINT BARS.

Basis of Purchase.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made in accordance with the terms of the specifications.

2. All tests and inspection shall be made at the place of manufacture prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

---

[5] Adopted, Vol. 12, 1916, Part 1, p. 469; Part 2, p. 14; Vol. 19, 1918, pp. 410, 1243.

[6] Adopted, Vol. 16, 1915, pp. 403, 1119.

Material.

3. Material for joint bars shall be steel, made by the Open-Hearth process.

Chemical Properties.

4. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Phosphorus, per cent., maximum 0.04.

5. The manufacturer shall furnish the inspector a complete report of ladle analysis, showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 4.

Physical Properties and Tests.

6. Joint bars shall conform to the following physical requirements:
   - (a) Tensile strength, lb. per square inch, minimum, 85,000.
   - (b) Elongation, per cent. in 2 inches, minimum, 16.
   - (c) Cold bending without fracture on the outside of the bent portion through 90 degrees around an arc the diameter of which is three times the thickness of the test piece.

7. All test pieces shall be cut from finished bars.
   - (a) Standard ½ by 2-inch specimens, as adopted by the American Society for Testing Materials, shall be used for tension test.
   - (b) The bend test specimen shall be ½ inch square in section, or a rectangular bar ½ inch thick, with two parallel faces as rolled.

General Requirements.

8. The different sections of joint bars shall be rolled to dimensions specified in drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber on either plant shall not exceed $\frac{1}{32}$ inch in 24 inches.

9. The joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛ inch.

10. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 degrees Centigrade (1470 degrees Fahrenheit).

(b) All bolt holes shall be punched in one operation, without bulging or distorting the section, and the bars shall be slotted for spikes when required, in accordance with the drawings, the slotting being done in one operation; a variation of $\frac{1}{32}$ inch in the size and location of the holes will be allowed.

11. All joint bars must be finished smooth and true, without swelling over or under the bolt holes, and be free from flaws, seams, checks or fins, and the fishing angles must be fully maintained.

12. The manufacturer's identification symbol, kind of material, month and year rolled and number of design, shall be rolled in raised letters and figures on each bar. The number of the melt shall be plainly stenciled on each lot of joint bars.

Inspection.

13. The joint bars from each melt shall be piled separately until tested and inspected by the purchaser's inspector. One joint bar for tension test shall be slected by the inspector for each melt represented in finished bars, or by agreement specimen for tension test may be cut from the bar as rolled. One joint bar for bend test shall be selected by the inspector for each lot of 1000 bars or less presented.

[7]SPECIFICATIONS FOR QUENCHED CARBON AND QUENCHED ALLOY STEEL TRACK BOLTS WITH NUTS.

Access to Works.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the bolts and nuts have been made in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspection shall be made at the place of manufacture, prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Rejection at Destination.

3. Bolts and nuts which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who shall pay the freight charges both ways.

---

[7] Adopted, Vol. 19, 1918, pp. 421, 1245.

Material.

4. Material for bolts shall be steel made by the Open-Hearth process or an acceptable alloy steel. It shall be homogeneous and when broken in tension, shall show a uniformly silky fracture. Material for the nuts shall be soft, untreated steel.

Chemical Properties.

5. The chemical composition of each melt of steel from which track bolts are manufactured shall be within the following limit:

Phosphorus, per cent., maximum............................0.04

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosphorus and sulphur content of each melt, represented in the finished material and any other elements used to obtain the specified physical properties. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 5. The drillings for check analysis shall be taken parallel to the axis and from the end of the finished bolt.

Physical Properties and Tests.

7. Track bolts shall conform to the following physical requirements:

	Carbon Steel.	*Alloy Steel.*
(a) Tensile strength, lb. per sq. in., minimum..	100,000	110,000
(b) Yield point, lb. per sq. in., minimum.....	70,000	85,000
(c) Elongation, per cent., in 2 inches, not less than....................................	$\frac{1,600,000}{\text{Ten. Str.}}$	
Minimum, 12 per cent.		
(d) Reduction in area, per cent. not less than..........		$\frac{3,500,000}{\text{Ten. Str.}}$

(e) Cold bending of the unthreaded portion of the finished bolt without fracture on the outside of the bent portion through 90 degrees around an arc, the diameter of which is three times the thickness of the test specimen.

8. All test specimens shall be from the finished bolts.

(a) The tension test specimens shall be about 4¼ in. long with threaded or unthreaded ends, and with the central 2-in. length turned to a ½-in. diameter, in accordance with the form and dimensions for tension test specimens of the American Society for Testing Materials.

(b) The yield point shall be determined by the strain gage.

Quenching.

9. (a) Track bolts shall be treated by quenching in oil or water, if so specified, from a temperature of about 810 degrees Centigrade

(1490 degrees Fahrenheit) and shall be kept in the bath until cold enough to be handled; a group thus treated being known as a quenching charge.

(b) Material which requires quenching in water will be acceptable at the option of the purchaser, provided it meets the requirements of the specification in all other respects.

General Requirements.

10. Track bolts and nuts shall be made to dimensions specified in drawing furnished by the purchaser with allowable variations in dimensions of bolts from standard as follows:

Length, ⅛-inch;
Diameter of shank, 1/64-inch;
Shoulder, 1/64-inch;
Diameter of rolled thread not more than 1/16-inch over the diameter of the body of ⅞-inch bolts;
Diameter of rolled thread not more than 3/32-inch over the diameter of the body of 1-inch bolts;
Variation in dimensions of elliptical shoulders under head of bolt of 1/32-inch.

11. The heads and nuts shall be free from checks or burrs of any kind. All finished pieces shall be smooth, straight, of uniform size, with well-shaped symmetrical bends and well-filled heads, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner. The head shall be concentric with and firmly joined to the bottom of the bolt with the underside of the head at right angles to the body of the bolt. The threads on the bolts shall be rolled, unless otherwise specified, shall be full and clean and shall be made in section and pitch according to the purchaser's standard. The fit between threads on the bolt and nut shall be accurate and nut shall go on with a 10-in. wrench from second to fifth turn. The force to turn the nut completely on the bolt with a 24-in. wrench shall not be more than 60 nor less than 40 lb.

12. (a) The nuts shall be made of soft untreated steel and shall be ¼-in. thicker than the standard nuts used for untreated bolts. They shall be of sufficient strength to develop the ultimate breaking strength of the bolts.

(b) Nuts of standard thickness will be accepted at the option of the purchaser if proved to be of sufficient strength to equal·the ultimate breaking strength of the bolts. The length of the bolts shall be correspondingly reduced.

Branding.

13. The heads of the bolts shall bear the manufacturer's identification symbol. The letter "Q" shall be used to show that the bolts have

been "quenched." If the bolts are also tempered, the letters "QT" shall be used to show that they have been "quenched and tempered."

Marking and Shipping.

14. When the bolts are shipped they shall have the nuts applied for at least two threads, be well oiled to prevent rust, and shall be packed in securely hooped kegs of 200 lb. net. All kegs shall be plainly marked as to material, size of bolts and name of manufacturer.

Inspection.

15. Tension and bend tests shall be made of the test specimens selected by the inspector from each lot of 50 kegs. One specimen shall be selected for each test, and if it meets the requirements of the specification, the lot will be accepted. If the test specimen fails, two additional specimens shall be tested in the same manner as the one which failed, and if they meet the requirements of the specification, the lot will be accepted. If, however, either one of the pieces fails, the lot will be rejected. Both tension and bend tests shall pass the requirements for acceptance.

[8]STANDARD TEST FOR RAIL JOINTS.

In order that comparison of results of different types of joint bars may be made, the uniform method of procedure for laboratory test shall be as follows:

General Assembly.

(1) Complete rail joints, full bolted, shall be used. Before joints are bolted the loose scale shall be removed from the contact surfaces of rails and joint bars so that there may be clean, dry surfaces for surface contact. Rail joints shall then be subjected to tests that will show the strength and deflection of the joint under transverse load with head up and also with head down.

(2) The results are to be compared with a test of a continuous rail of the same span for determination of rail joint efficiency and rigidity.

(3) The joints are to be bolted with heat treated bolts, or if other bolts are used, the quality and kind of bolt shall be stated.

(4) The rail used for test of joints shall be cut from the same piece of rail as rail for continuous span. Rails used for test pieces shall preferably be from the same rail or at least from the same heat of rails. New rails and joint bars shall be used for test.

---

[8] Adopted, Vol. 20, 1919, pp. 463, 884.

Quality of Material.

(5) Material for both rail and joint bars shall be subjected to standard tension tests, to hardness tests, to chemical analysis and, if heated treated material, to microscopic examination.

(6) Measurements to be recorded for joint bars of the area sketch of section, moment of inertia, length, weight, location of bolt holes, camber, if any.

(7) Measurements of rail section include area sketch of section, moment of inertia, weight per yard, location and size of bolt holes.

(8) Joints are to be bolted up so that there shall be a space of ⅜ of an inch between the ends of the adjoining rails. Bolts are to be applied so that they shall not be in contact with the sides of the bolt holes through the rails. If necessary, ends of rails to be faced off to give required spacing and bolt clearance.

(9) The supports shall be solid, flat bearing surfaces with vertical faces 48 in. apart, with the inner edges rounded off to ⅛ of an inch radius. The load to be applied midway between the supports by a block, having a radius of 16½ inches, and a width not less than the width of the base of the rail.

Loading.

(10) An initial load of 3,000 lb. shall be made, at which load the deflectometer shall be set at zero. Uniform increments of load of such magnitude shall then be applied to accurately define the elastic limit. Maximum deflection and set to be determined for each increment of loading. Deflections and permanent sets to be measured to one-thousandths of an inch. Loading to continue until adjacent rail ends meet.

(11) Note is to be made of readings of the load at which the joint bars or rails commence to scale.

Number of Tests.

(12) Three concordant tests shall be made, and results shall be recorded in detail. Abnormal tests to be discarded.

Efficiency.

(13) The efficiency of a rail joint is expressed as the ratio of the elastic limit in pounds of the rail joint divided by the elastic limit of the continuous rail; this efficiency to be given first with head up, second with head down, using data to correspond to conditions imposed. Rail joint efficiencies shall be expressed in per cent.

Rigidity.

(14) The rigidity of a joint is a comparison of the deflections of the rail and the joint under the load that develops the elastic limit of the joint. It is the ratio expressed in per cent., of the deflection of the rail to the deflection of the joint at this loading; that is, the deflection of the rail divided by the deflection of the joint at the elastic limit of the joint.

(15) The rigidity shall be expressed for the two conditions of test, with head up and with head down.

[9]SPECIFICATIONS FOR MEDIUM CARBON STEEL TRACK BOLTS WITH NUTS.

Access to Works.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the bolts and nuts have been made in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspection shall be made at the place of manufacture, prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Rejection at Destination.

3. Bolts and nuts which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who shall pay the freight charges both ways.

Material.

4. Material for bolts shall be steel made by the Open-Hearth or Bessemer process. It shall be homogeneous and when broken in tension shall show a uniformly silky fracture. Material for nuts shall be of soft steel.

Chemical Properties.

5. The chemical composition of each melt of steel from which track bolts are manufactured shall be within the following limits:

Phosphorus, Maximum	Per Cent.
Open-Hearth	0.05
Bessemer	0.10

---

[9] Adopted, Vol. 19, 1918, pp. 423, 1246.

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosporus and sulphur content of each melt represented in the finished material and any other elements used to obtain the specified physical properties. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 5. The drillings for check analysis shall be taken parallel to the axis and from the end of the finished bolt.

Physical Properties and Tests.

7. Track bolts shall conform to the following physical requirements:

(a) Tensile strength, lb. per sq. in., minimum......... 55,000
(b) Yield point not less than 50 per cent. of the ultimate breaking stress ....
(c) Elongation, per cent. in 2 inches, not less than...... $\frac{1,500,000}{\text{Ten. Str.}}$
Minimum, 20 per cent.
(d) Reduction in area not less than.................... $\frac{2,200,000}{\text{Ten. Str.}}$
Minimum, 30 per cent.
(e) Cold bending of the unthreaded part of the finished bolt without sign of fracture on the outside of the bent portion, through 180 degrees flat on itself.

8. All test specimens shall be from the finished bolts.

(a) The tension test specimens shall be about 4¼ in. long with threaded or unthreaded ends, and with the central 2-inch length turned to a ½-in. diameter, in accordance with the form and dimensions for tension test specimens of the American Society for Testing Materials.

General Requirements..

9. Track bolts and nuts shall be made to dimensions specified in drawing furnished by the purchaser, with allowable variation in dimensions of bolts from standard as follows:

Length, ⅛-inch;
Diameter of shank, 1/64-inch;
Shoulder, 1/64-inch;
Diameter of rolled thread not more than 1/16-inch over the diameter of the body of ⅞-inch bolts;
Diameter of rolled thread not more than 3/32-inch over the diameter of the body of 1-inch bolts;
Variation in dimensions of elliptical shoulders under head of bolt of 1/32-inch.

10. The heads and nuts shall be free from checks or burrs of any kind. All finished pieces shall be smooth, straight, of uniform size, with well-shaped symmetrical bends and well-filled heads, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner. The head shall be concentric with and firmly joined to the bottom of the bolt, with the underside of the head at right angles to the

body of the bolt. The threads on bolts shall be rolled, unless otherwise specified; shall be full and clean and shall be made in section and pitch according to the purchaser's standard. The fit between threads on the bolt and nut shall be accurate and nut shall go on with a 10-in. wrench from second to fifth turn. The force to turn the nut completely on the bolt with a 24-in. wrench shall not be more than 60 nor less than 40 lb.

11. The nuts shall be made of soft, untreated steel and shall be of sufficient strength to develop the ultimate breaking strength of the bolts.

Branding.

12. Manufacturer's identification shall appear on the head of each bolt.

Marking and Shipping.

13. When the bolts are shipped they shall have the nuts applied for at least two threads, be well oiled to prevent rust, and shall be packed in securely hooped kegs of 200 lb. net. All kegs shall be plainly marked as to material, size of bolts and name of manufacturer.

Inspection.

14. Tension and bend tests shall be made of the test specimens selected by the inspector from each lot of 50 kegs. One specimen shall be selected for each test, and if they meet the requirements of the specifications the lot will be accepted. If one of the test specimens fails, two additional specimens shall be tested in the same manner as the one which failed, and if they meet the requirements of the specifications, the lot will be accepted. If, however, either one of the specimens fails, the lot will be rejected. Both tension and bend tests shall pass the requirements for acceptance.

[10]SPECIFICATIONS FOR QUENCHED CARBON AND QUENCHED ALLOY STEEL JOINT BARS.

Access to Works.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspection shall be made at the place of manufac-

---

[10] Adopted, Vol. 19, 1918, pp. 417, 1245.

ture, prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Rejection at Destination.

3. Joint bars which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who shall pay the freight charges both ways.

Material.

4. Material for joint bars shall be steel made by the Open-Hearth process or an acceptable alloy steel.

Chemical Properties.

5. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Carbon, per cent	0.42 to 0.55
Phosphorus, per cent., maximum	0.04

Note.—In the event of nickel and chromium being present to the extent of 1.00 per cent. and 0.35 per cent., respectively, these elements will be considered as the equivalent of 0.07 per cent. of carbon in the above requirements.

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 5.

Physical Properties and Tests.

7. Joint bars shall conform to the following physical requirements:

	Quenched Steel.	*Alloy Steel.*
(a) Tensile strength, lb. per sq. in., minimum	100,000	110,000
(b) Elastic limit, lb. per sq. in., minimum	70,000	85,000

(c) Elongation, per cent. in 2 inches, not less than $\frac{1{,}600{,}000}{\text{Ten. Str.}}$

Minimum, 12 per cent.

(d) Reduction in area, per cent. not less than $\frac{3{,}500{,}000}{\text{Ten. Str.}}$

Minimum, 25 per cent.

(e) Cold bending of the quenched bar without sign of fracture on the outside of the bent portion through 90 degrees around an arc, the diameter of which is three times the thickness of the test specimen.

8. All test specimens shall be cut from finished bars.

(a) The tension test specimens shall be about 4¼ inches long with threaded or unthreaded ends, and with the central 2-in. length turned to a ½-in. diameter, in accordance with the form and dimensions for tension test specimens of the American Society for Testing Materials.

(b) The bend test specimens shall be ½-in. square in section or a rectangular bar ½-in. thick with two parallel faces as rolled.

(c) The elastic limit shall be determined by the use of the Berry strain gage, or similar instrument, and will be the load when the elongation shows a change in the rate of stretch, the machine being operated at not more than ¼-in. per minute. After the elastic limit is reached the speed shall not exceed 2 in. per minute.

Quenching.

9. (a) Joint bars shall be quenched in oil, or water if so specified, from a temperature of about 810 degrees Centigrade (1490 degrees Fahrenheit) and shall be kept in the bath until cold enough to be handled. A group thus treated is known as a quenching charge.

(b) Material which requires quenching in water will be acceptable at the option of the purchaser, provided it meets the requirements of the specification in all other respects.

General Requirements.

10. Joint bars shall be rolled to dimensions specified in drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber in either plane shall not exceed 1/32-in. in 24 in.

11. Joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛-in.

12. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 degrees Centigrade (1470 degrees Fahrenheit).

(b) All bolt holes shall be punched in one operation without bulging or distorting the section, and the bars shall be slotted when required for spikes in accordance with the purchaser's drawing, the slotting being done in one operation. A variation of 1/32-in. in location of the holes will be allowed.

13. All types of joint bars shall be finished smooth and true without swelling over or under the bolt holes, and shall be free from flaws, seams, checks or fins. The fishing angles shall be fully maintained.

Branding.

14. The rolled bar shall be branded or marked for identification in the following manner and a portion of this marking shall appear on each finished joint bar:

(a) A portion of the name of the manufacturer, the year of manufacture, the numbered design and the kind of material shall be rolled in raised letters and figures on the outside of the bars.

(b) The letters "O H" shall be used to indicate "Open-Hearth Steel."

(c) The letter "Q" shall be used to show that the joint bars have been "quenched." If the joint bars are also tempered, the letters "QT" shall be used to show that they have been "quenched and tempered."

(d) The number of the melt shall be plainly stenciled on each lot of bars.

Inspection.

15. The joint bars from each melt or heat treatment lot shall be piled separately until tested and inspected by the inspector. One joint bar for tension test shall be selected by the inspector for each melt or heat treatment lot represented in finished bars. One joint bar for bend test shall be selected by the inspector for each lot of 1000 bars or less presented or from each heat treatment lot.

[11]RAIL RECORD FORMS.

(1) The following forms are considered essential and are recommended for keeping rail statistics and records:

Group 1—Inspection and Shipment:

401-A, Mill Inspection.
401-B, Certificate of Inspection.
401-C, Report of Shipment.
401-D, Tabulation of Results of Mill Inspections of Rail.
401-E, Yearly Summary of Mill Inspections of Rail.

Group 2—Rail Failures:

402-A, Track Foreman's Report of Rail Failure.
402-B, Monthly Summary of Rail Failures.
402-C, Yearly Summary of Rail Failures.
402-D, Statement of Rails in Main Tracks.

Group 3—Rail Wear:

403-A, Diagram of Location of Rails.
403-B, Diagram of Lines of Wear.
403-C, Record of Wear.

EXPLANATION OF FORMS.

As will be noted above, the Rail Record forms are divided into three groups as follows:

401—Mill Inspection and Shipment.

402—Rail Failures.

403—Rail Wear.

Group 1.

401-A, Report of Chemical and Physical Tests of Rails.

This form gives the Inspector's reports of chemical, physical and other tests of rails on which acceptance or rejection is based.

---

[11] Adopted, Vol. 10, 1909, pp. 339-363, 375, 393-395; Vol. 11, Part 2, 1910, pp. 241-251, 576-579; Vol. 12, 1912, Part 1, p. 467, Part 2, p. 17; Vol. 22, 1921, pp. 202, 986.

401-B, Certificate of Inspection of Rails.

This form gives a statement of the amount of rails accepted and rejected of each class, tonnages, etc.

401-C, Report of Shipment of Rails.

This form gives the details of the rails loaded into each car for shipment. When properly checked by the receiving officer it furnishes the basis for the payment of the invoice.

401-D, Tabulation of Results of Mill Inspections of Rail.

This form is a tabulation of the results of the mill inspections of rails covering in general the results for several days' rolling, or rollings distributed over several weeks. The form may be varied to suit the specifications to which the rails are rolled.

401-E, Summary of Mill Inspection of Rails.

This form is for an annual report by each railway to the American Railway Association covering the main results of the mill inspection of rails.

Group 2.

402-A, Report of Rail Failures in Main Track.

This form is intended for use by the Track Foreman to report each rail failure as it occurs in the track. It is the basic report from which monthly and annual summaries are made.

402-B, Rail Failures for the Month.

This form is a monthly summary of the rail failures on a division.

402-C, Rail Failures for the Year.

This form is an annual summary of the rail failures and is used by each railway to make an annual report to the American Railway Association.

402-D, Statement of Steel Rails in Main Tracks.

This form is a statement showing the rails existing in the tracks at the end of the year.

Group 3.

403-A, Location Diagram.

This is a form on which may be drawn a diagram showing the location of the rails in test.

403-B, Diagram Showing Lines of Wear.

This form contains sections of the rails being tested and on which the progressive wear may be shown. The diagram should be of the section of the rail under test.

403-C, Statement of Comparative Wear of Test Rail.

This form is a tabulation of the results of tests of wear.

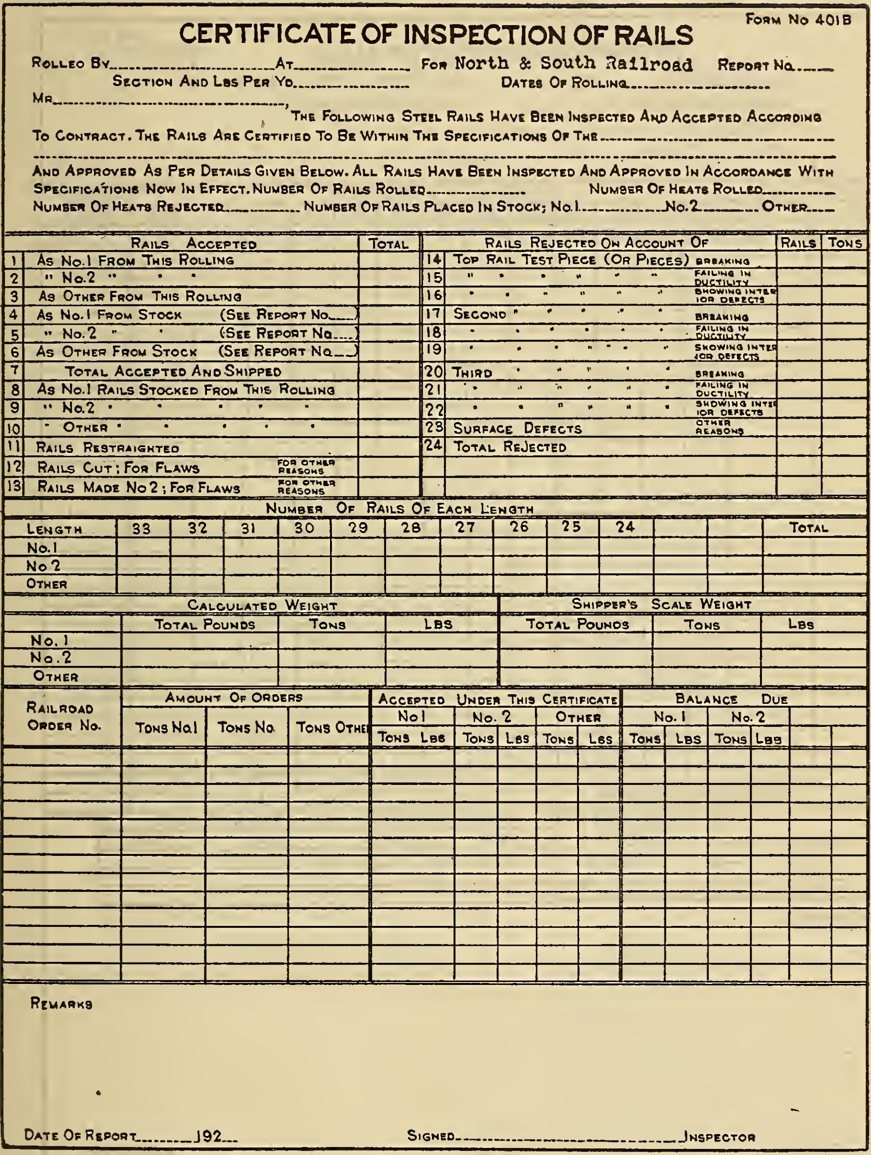
Form 401A

REPORT OF CHEMICAL AND PHYSICAL TESTS OF RAILS

Rolled By.......................At.......................For North & South Railroad Report No.....
Height Of Drop.......Ft. Span Of Supports.......Ft. Section And Weight Per Yard Of Rail......, Date Of Rolling..............
Specifications Used.......................................Maximum Shrinkage Allowed On 33 Ft. Rails..............Inchs
Size Of Ingots....By....Inchs; Nominal Discard From Ingot.......Percent From Top....Percent From Bottom; Nominal No. Of Rails Per Ingot...

Heat No.	No. Of Ingots	No. Of Rails	Chemical Analysis														Ingot No. In Heat	Head Up Or Base Up	Drop Test Blow No.	Perm Set Inchs	Elongation In Inchs							Remarks Showing Disposition Of Rails After Testing
			C		Mn		P		S		Si.										1st	2nd	3rd	4th	5th	6th	Total Elongation	
			L	R	L	R	L	R	L	R	L	R	L	R	L	R												
Spec'ns																												
1																												
2																												
3																												
4																												
5																												
6																												
7																												
8																												
9																												
10																												
11																												
12																												
13																												
14																												
15																												
16																												
17																												
18																												
19																												
20																												
21																												
22																												
23																												
24																												
25																												
26																												
27																												
28																												
29																												
30																												
31																												
32																												

Date Of Report..........192..; 'L' Means Ladle Test; R. Means Rail Analysis Signed..............................Inspector



Form No 401B

CERTIFICATE OF INSPECTION OF RAILS

Rolled By____________At__________ For North & South Railroad Report No.____

Section And Lbs Per Yd.__________ Dates Of Rolling____________

Mr.____________________,

The Following Steel Rails Have Been Inspected And Accepted According To Contract. The Rails Are Certified To Be Within The Specifications Of The____________________ And Approved As Per Details Given Below. All Rails Have Been Inspected And Approved In Accordance With Specifications Now In Effect. Number Of Rails Rolled__________ Number Of Heats Rolled________ Number Of Heats Rejected________ Number Of Rails Placed In Stock; No.1________No.2_______ Other____

	Rails Accepted	Total		Rails Rejected On Account Of		Rails	Tons
1	As No.1 From This Rolling		14	Top Rail Test Piece (Or Pieces)	Breaking		
2	" No.2 " " "		15	" " " " " "	Failing In Ductility		
3	As Other From This Rolling		16	" " " " " "	Showing Interior Defects		
4	As No.1 From Stock (See Report No.___)		17	Second " " " " "	Breaking		
5	" No.2 " " (See Report No.___)		18	" " " " " "	Failing In Ductility		
6	As Other From Stock (See Report No.___)		19	" " " " " "	Showing Interior Defects		
7	Total Accepted And Shipped		20	Third " " " " "	Breaking		
8	As No.1 Rails Stocked From This Rolling		21	" " " " " "	Failing In Ductility		
9	" No.2 " " " "		22	" " " " " "	Showing Interior Defects		
10	" Other " " " "		23	Surface Defects	Other Reasons		
11	Rails Restraighted		24	Total Rejected			
12	Rails Cut: For Flaws / For Other Reasons						
13	Rails Made No 2; For Flaws / For Other Reasons						

Number Of Rails Of Each Length

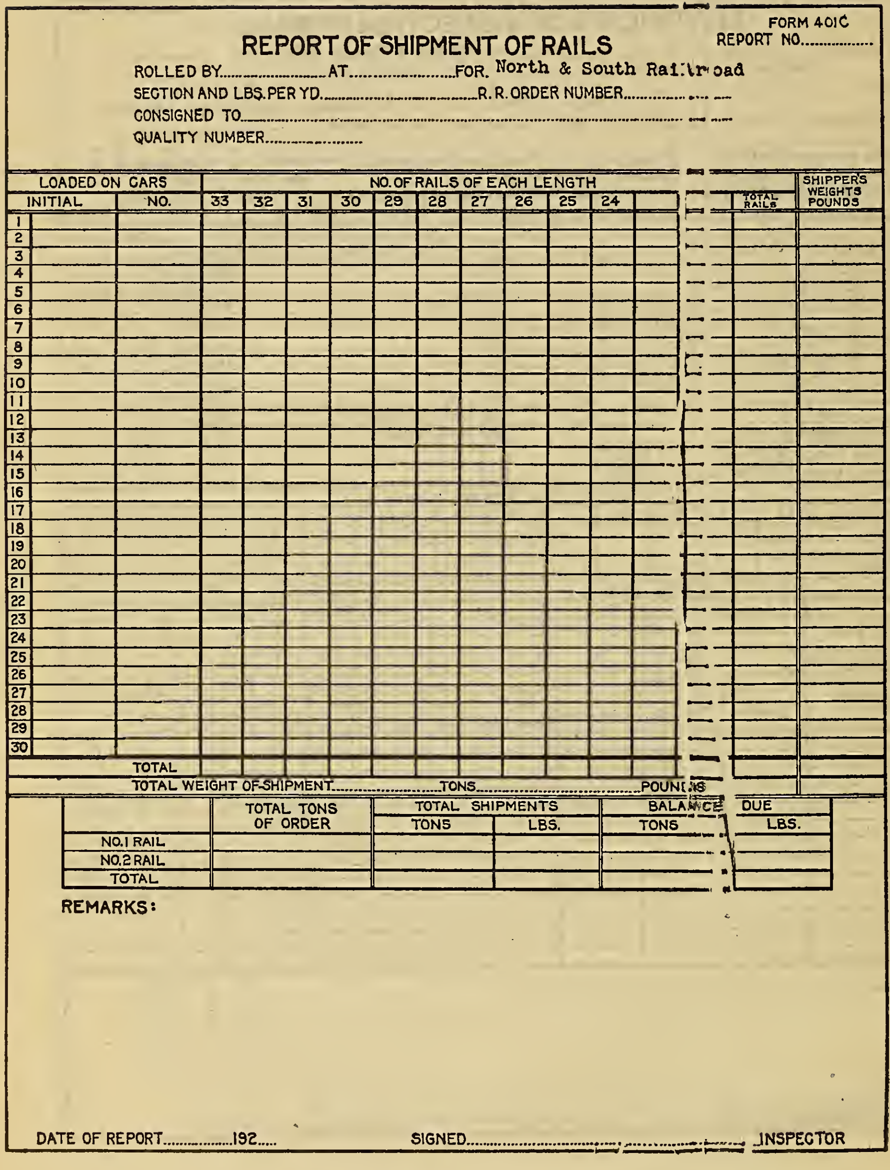
Length	33	32	31	30	29	28	27	26	25	24			Total
No.1													
No 2													
Other													

	Calculated Weight			Shipper's Scale Weight		
	Total Pounds	Tons	Lbs	Total Pounds	Tons	Lbs
No. 1						
No. 2						
Other						

Railroad Order No.	Amount Of Orders			Accepted Under This Certificate						Balance Due					
				No 1		No. 2		Other		No. 1		No. 2			
	Tons No.1	Tons No.	Tons Othe	Tons	Lbs	Tons	Lbs	Tons	Lbs	Tons	Lbs	Tons	Lbs		

Remarks

Date Of Report_______192__ Signed____________________Inspector



FORM 401C
REPORT NO.................

REPORT OF SHIPMENT OF RAILS

ROLLED BY.......................AT.......................FOR. North & South Railroad
SECTION AND LBS. PER YD.................................R. R. ORDER NUMBER...................
CONSIGNED TO..
QUALITY NUMBER.......................

LOADED ON CARS			NO. OF RAILS OF EACH LENGTH													SHIPPER'S WEIGHTS POUNDS
	INITIAL	NO.	33	32	31	30	29	28	27	26	25	24			TOTAL RAILS	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																
		TOTAL														

TOTAL WEIGHT OF SHIPMENT.......................TONS.......................................POUNDS

	TOTAL TONS OF ORDER	TOTAL SHIPMENTS		BALANCE DUE	
		TONS	LBS.	TONS	LBS.
NO. 1 RAIL					
NO. 2 RAIL					
TOTAL					

REMARKS:

DATE OF REPORT..................192.....
SIGNED...INSPECTOR

Tabulation of Results of Mill Inspections of Rail

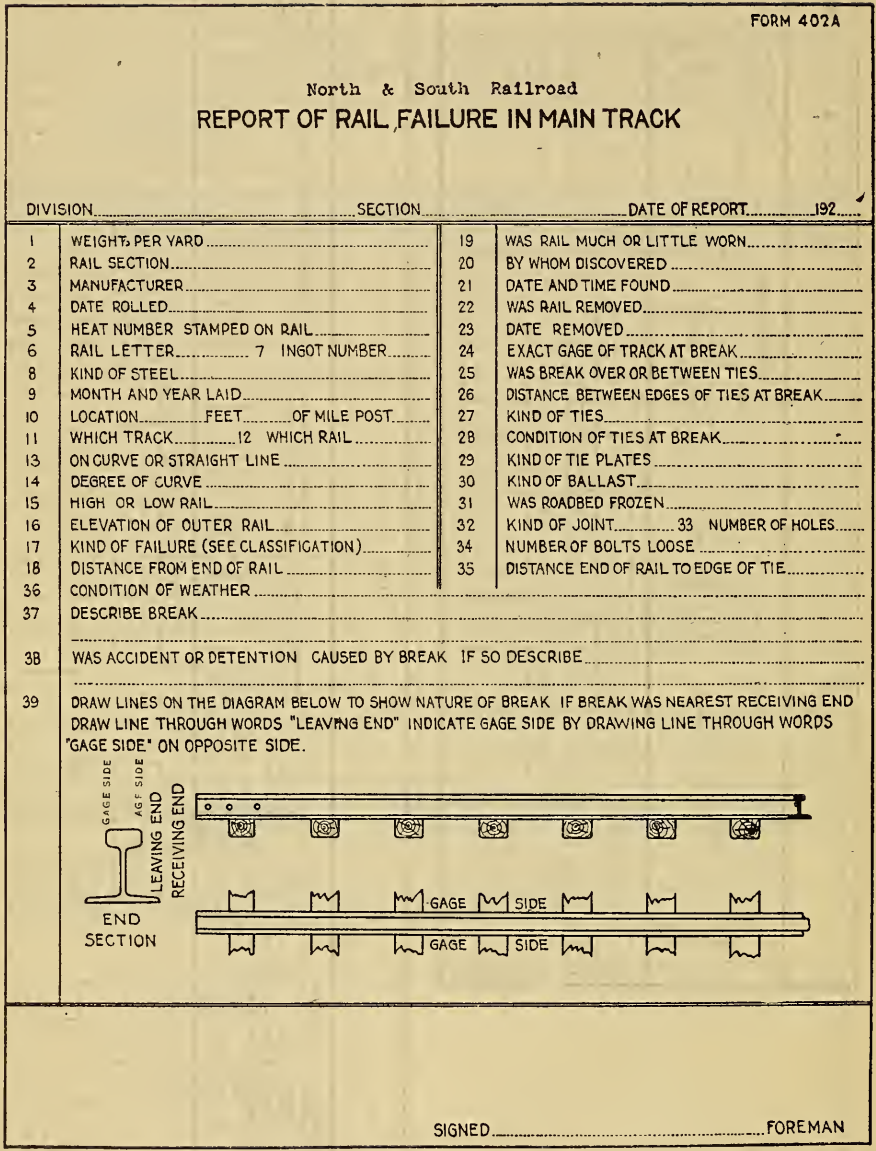
Line No.	Inspector's Report Number	Name Of Company And Mill Where Rolled	Rail			No. Of Tons Ordered	No. Of Tons Ordered							No. Of Tons Rejected –		No. Of Tons Rolled And Submitted To Inspector.	No. Of Rails Accepted			
			Weight	Section	Kind Of Metal		No 1		No. 2		Other		Total Tons	Number	% Of Total Rolled		No. 1 Rails	No. 2 Rails	Other Rails	Other Rails
							Tons	% Of Total	Tons	% Of Total	Tons	% Of Total								
1																				
2																				
3																				
4																				
5																				
43																				
44																				
45																				
46																				
47																				
48																				

Rolled from.............. ....192.... to..192....

Form 401D

Total Number	% Of Total Rolled	Number Of Rails Rejected														Permanent Set Under First Blow Inches				Exhausted Elongation Percent In Maximum Inchs				Average Analysis Of Heats Accepted														Average Discard From Ingots		Average No. Of Ingots In Heat	Normal No. Of Rails Per Ingot	Size Of Ingots	No. Of Heats Rolled
		Top Rails				Second Rail				Third Rail				Surface Imperfection		No. Of Pieces Tested	Max.	Min.	Average	No. Of Pieces	Highest	Lowest	Average	C		P		Mn		Si		S						% Top	% Bottom				
		Failing In Elongation		Showing Interior Defect		Failing In Elongation		Showing Interior Defect		Failing In Elongation		Showing Interior Defect																															
		No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject	No.	% Of Total Reject									L	R	L	R	L	R	L	R	L	R	L	R	L	R						

"L" Means Ladle Test; "R" Means Rail Test.



FORM 402A

North & South Railroad

REPORT OF RAIL FAILURE IN MAIN TRACK

DIVISION................................SECTION................................DATE OF REPORT..............192.....

1 WEIGHT PER YARD..............................

2 RAIL SECTION..............................

3 MANUFACTURER..............................

4 DATE ROLLED..............................

5 HEAT NUMBER STAMPED ON RAIL..............................

6 RAIL LETTER.............. 7 INGOT NUMBER..............

8 KIND OF STEEL..............................

9 MONTH AND YEAR LAID..............................

10 LOCATION..............FEET..............OF MILE POST..............

11 WHICH TRACK..............12 WHICH RAIL..............

13 ON CURVE OR STRAIGHT LINE..............................

14 DEGREE OF CURVE..............................

15 HIGH OR LOW RAIL..............................

16 ELEVATION OF OUTER RAIL..............................

17 KIND OF FAILURE (SEE CLASSIFICATION)..............................

18 DISTANCE FROM END OF RAIL..............................

19 WAS RAIL MUCH OR LITTLE WORN..............................

20 BY WHOM DISCOVERED..............................

21 DATE AND TIME FOUND..............................

22 WAS RAIL REMOVED..............................

23 DATE REMOVED..............................

24 EXACT GAGE OF TRACK AT BREAK..............................

25 WAS BREAK OVER OR BETWEEN TIES..............................

26 DISTANCE BETWEEN EDGES OF TIES AT BREAK..............................

27 KIND OF TIES..............................

28 CONDITION OF TIES AT BREAK..............................

29 KIND OF TIE PLATES..............................

30 KIND OF BALLAST..............................

31 WAS ROADBED FROZEN..............................

32 KIND OF JOINT..............33 NUMBER OF HOLES..............

34 NUMBER OF BOLTS LOOSE..............................

35 DISTANCE END OF RAIL TO EDGE OF TIE..............................

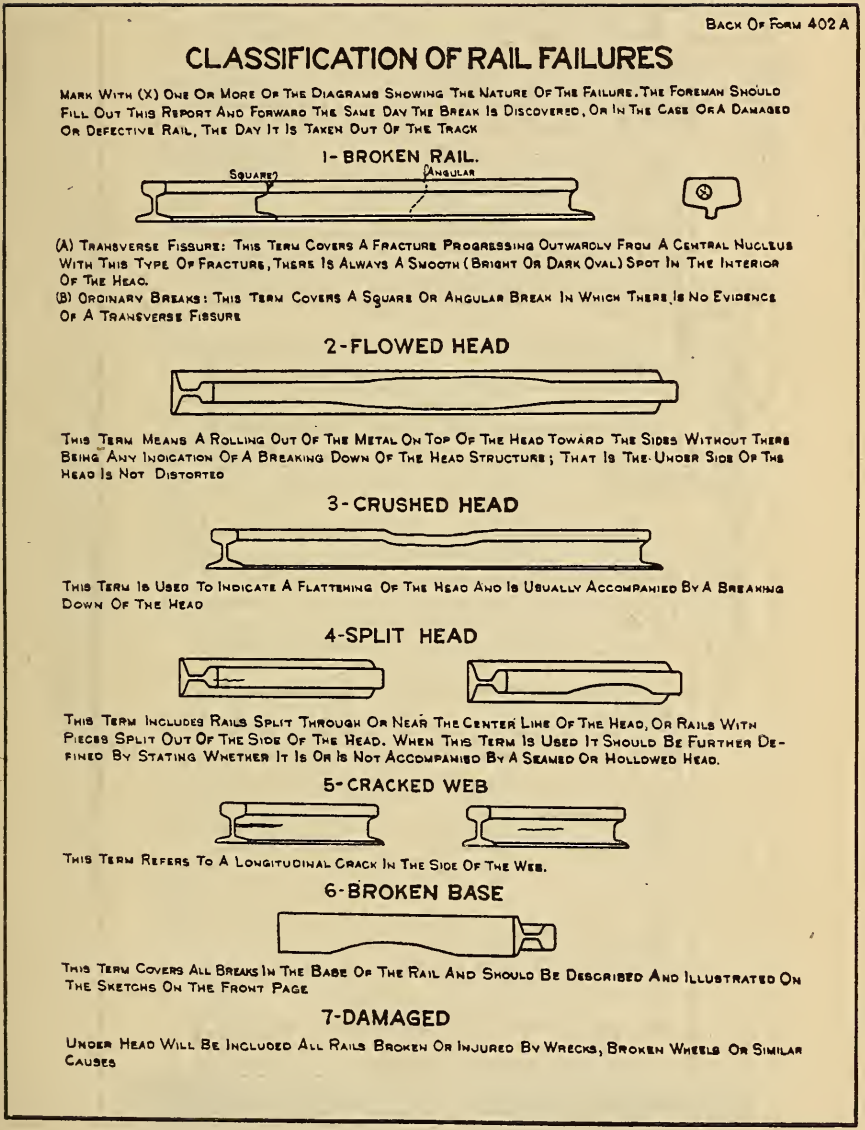
36 CONDITION OF WEATHER..............................

37 DESCRIBE BREAK..............................

38 WAS ACCIDENT OR DETENTION CAUSED BY BREAK IF SO DESCRIBE..............................

39 DRAW LINES ON THE DIAGRAM BELOW TO SHOW NATURE OF BREAK IF BREAK WAS NEAREST RECEIVING END DRAW LINE THROUGH WORDS "LEAVING END" INDICATE GAGE SIDE BY DRAWING LINE THROUGH WORDS "GAGE SIDE" ON OPPOSITE SIDE.

SIGNED..............................FOREMAN



Back Of Form 402 A

CLASSIFICATION OF RAIL FAILURES

Mark With (X) One Or More Of The Diagrams Showing The Nature Of The Failure. The Foreman Should Fill Out This Report And Forward The Same Day The Break Is Discovered, Or In The Case Of A Damaged Or Defective Rail, The Day It Is Taken Out Of The Track

1- BROKEN RAIL.

Square
Angular

(A) Transverse Fissure: This Term Covers A Fracture Progressing Outwardly From A Central Nucleus With This Type Of Fracture, There Is Always A Smooth (Bright Or Dark Oval) Spot In The Interior Of The Head.

(B) Ordinary Breaks: This Term Covers A Square Or Angular Break In Which There Is No Evidence Of A Transverse Fissure

2-FLOWED HEAD

This Term Means A Rolling Out Of The Metal On Top Of The Head Toward The Sides Without There Being Any Indication Of A Breaking Down Of The Head Structure; That Is The Under Side Of The Head Is Not Distorted

3-CRUSHED HEAD

This Term Is Used To Indicate A Flattening Of The Head And Is Usually Accompanied By A Breaking Down Of The Head

4-SPLIT HEAD

This Term Includes Rails Split Through Or Near The Center Line Of The Head, Or Rails With Pieces Split Out Of The Side Of The Head. When This Term Is Used It Should Be Further Defined By Stating Whether It Is Or Is Not Accompanied By A Seamed Or Hollowed Head.

5-CRACKED WEB

This Term Refers To A Longitudinal Crack In The Side Of The Web.

6-BROKEN BASE

This Term Covers All Breaks In The Base Of The Rail And Should Be Described And Illustrated On The Sketchs On The Front Page

7-DAMAGED

Under Head Will Be Included All Rails Broken Or Injured By Wrecks, Broken Wheels Or Similar Causes

FORM 401E

SUMMARY OF MILL INSPECTIONS OF RAIL

Rolled For North & South Railroad During Year Ending Dec.31, 192...

MILL	RAILROAD	KIND OF STEEL	SPECIFICATIONS USED	POUNDS PER YARD	SECTION	SPECIFIED CARBON		AV. TOP DISCARD PER CENT.	ACCEPTED-TONS				AV. ELONG. OF ACCEPTED RAILS PER CENT.	REJECTED							TOTAL TONS ROLLED	PER CENT. REJECTED OF TOTAL ROLLED	PER CENT. NO.2 OF TOTAL TONS ROLLED	REMARKS
						MIN.	MAX		NO.1	NO.2	OTHER RAILS	TOTAL		TONS				PER CENT OF TOTAL TONS						
														A RAILS	B RAILS	OTHER RAILS	TOTAL	A RAILS	B RAILS	OTHER RAILS				

REMARKS:

INSTRUCTIONS

1. ATTACH TO THIS REPORT A COPY OF THE RAIL SPECIFICATIONS USED
2. FILL IN THIS SHEET SO BLUEPRINTS CAN BE MADE OF IT. USE INDIA INK, OR IF TYPEWRITTEN, FACE THE UNDER SIDE OF THIS SHEET WITH BLACK CARBON PAPER
3. FILL IN EACH LINE WITHOUT USING DITTO MARKS FOR SORTING AND TABULATING, THE PRINTS ARE TO BE CUT ALONG THE HORIZONTAL LINES, AND EACH STRIP SHOULD HAVE ITS INFORMATION COMPLETE.
4. UNDER "KIND OF STEEL," SHOW WHETHER OPEN-HEARTH, BESSEMER, ELECTRIC, ALLOY, SPECIAL TREATMENT, OR OTHERWISE
5. UNDER "AVERAGE TOP DISCARD," SHOW THE AVERAGE PER CENT. OF DISCARD FROM THE TOP OF THE INGOT, INCLUDING CROPPINGS FROM BOTH THE BLOOM AND THE RAIL-BAR
6. THE "AVERAGE ELONGATION OF ACCEPTED RAILS" REFERS TO THE EXHAUSTED DUCTILITY OF RAILS TESTED TO DESTRUCTION IN THE DROP TEST, AND WHICH IN ANY GIVEN PIECE IS THE MAXIMUM PER CENT. OF STRETCH IN ANY ONE INCH OF THE USUAL SIX SPACES OF ONE INCH EACH.
7. IN EXPRESSING TONS, USE WHOLE NUMBERS IN EXPRESSING PER CENTS, USE WHOLE NUMBERS AND TENTHS.
8. IN CASE OF DOUBT AS TO THE INTERPRETATION OF ANY OF THE ITEMS ON THIS FORM, WRITE TO ENGINEER OF TESTS, RAIL COMMITTEE, AMERICAN RAILROAD ASSOCIATION, SECTION II, ENGINEERING, ROOM 1426, 431 SOUTH DEARBORN STREET, CHICAGO, ILLINOIS

FORM 402B

North & South Railroad

RAIL FAILURES FOR THE MONTH OF..............192....ON......................DIVISION

LINE NUMBER	REPORT NUMBER	DESCRIPTION OF RAIL										LOCATION OF RAIL					DATE LAID		DAY OF MONTH FOUND	TIME IN SERVICE		NATURE OF FAILURE								IN JOINT	OUT OF JOINT
		WT. PER YARD	TYPE OF SECTION	MARKS ON RAIL							LENGTHS	MILE POST		WHICH TRACK	CURVE OR TANGENT	DEGREE OF CURVE	MO.	YEAR		YEAR	MO.	TRANS. FISSURE	BROKEN, ORDINARY	FLOWED HEAD	CRUSHED HEAD	SPLIT HEAD	CRACKED WEB	BROKEN BASE	DAMAGED		
				MANUFACTURER	ROLLED		KIND OF STEEL	HEAT NO.	INGOT NO.	RAIL LETTER		NO.	FEET																		
					MO.	YEAR																									
1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															
12																															
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															
21																															
22																															
23																															
24																															
25																															
																					TOTAL FAILURES →										
																						GRAND TOTALS OF FAILURES FOR MONTH									

DATE OF STATEMENT............192....

Form 402-C

Rail Failures for the Year Ending October 31, 19

________________________ Railroad

Kind of Steel	Mill	Year Rolled	Pounds Per Yard	Section	Railroad	Tons New Rail Laid	Equivalent Track Miles	Specified Carbon		Period	Number of Failures																									Failures per 100 Track Miles of New Rail Laid
											Head					Web					Base					Broken					Total					
								Min.	Max.		A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	A	B	L	U	Total	
										This Year																										
										Total to Date																										
										This Year																										
										Total to Date																										
										This Year																										
										Total to Date																										

FORM 402D

North & South Railroad

STATEMENT OF RAILS IN MAIN TRACKS OF...DIVISION

....MAIN TRACK DECEMBER 31, 19.......

	LOCATION							YEAR LAID	MILL	ROLLED		WEIGHT PER YARD	TYPE OF SECTION	TRACK FEET		REMARKS
	MILE POST				MILES	NEAREST STATION				MONTH	YEAR			LAID PREVIOUS TO 19	NEW STEEL LAID 19	
	FROM		TO													
	M.P.	+FT.	M.P.	+FT.		FROM	TO									
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																

..........................FT..............LB RAIL=....................TRACK MILES

.... " .... " " =.................... " "

.... " .... " " =.................... " "

.... " .... " " =.................... " "

FORM 403A

North & South Railroad

..........DIVISION

LOCATION DIAGRAM

OF

..........RAILS..........TONS

LAID..........REMOVED..........

BETWEEN..........AND..........

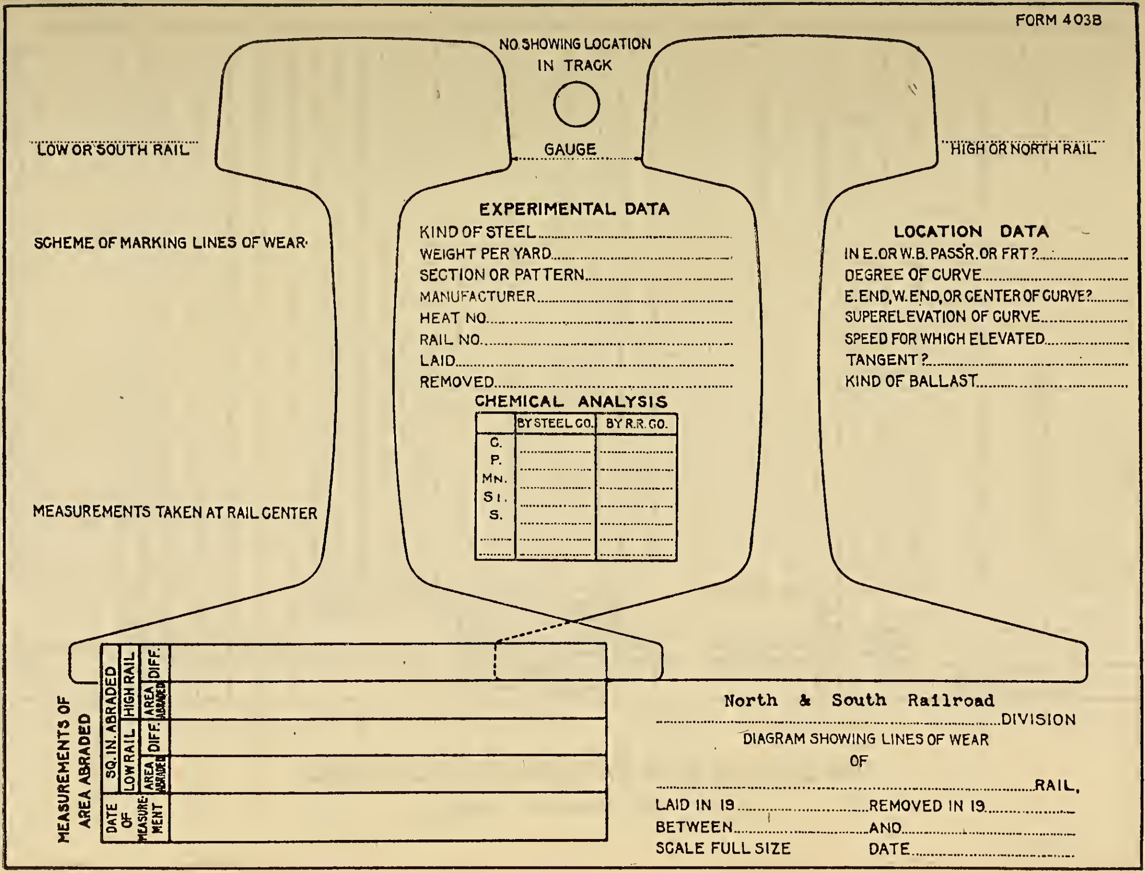
DATE..........

A=..........SHOWN IN RED B=..........SHOWN IN YELLOW

SUMMARY

MONTH AND YEAR →												
KIND OF RAIL →	A	B	A	B	A	B	A	B	A	B	A	B
TOTAL SQ. IN. ABRADED. AVER. SQ. IN. ABRADED PER SEC. AREA ABRADED IN PERCENTAGE OF ORIGINAL AREA OF HEAD. TOTAL TONNAGE TO DATE.												

"TONNAGE"= TOTAL TONS (INCLUDING LOCOMOTIVES AND CABOOSE CARS) OVER EXPERIMENT FROM DATE LAID TO DATE OF REPORT, EXPRESSED IN UNITS OF 10,000 TONS.



FORM 403B

NO. SHOWING LOCATION IN TRACK

GAUGE

LOW OR SOUTH RAIL

HIGH OR NORTH RAIL

SCHEME OF MARKING LINES OF WEAR.

MEASUREMENTS TAKEN AT RAIL CENTER

EXPERIMENTAL DATA

KIND OF STEEL..........

WEIGHT PER YARD..........

SECTION OR PATTERN..........

MANUFACTURER..........

HEAT NO..........

RAIL NO..........

LAID..........

REMOVED..........

CHEMICAL ANALYSIS

	BY STEEL CO.	BY R.R. CO.
C.		
P.		
MN.		
SI.		
S.		

LOCATION DATA

IN E. OR W.B. PASS'R. OR FRT?..........

DEGREE OF CURVE..........

E. END, W. END, OR CENTER OF CURVE?..........

SUPERELEVATION OF CURVE..........

SPEED FOR WHICH ELEVATED..........

TANGENT?..........

KIND OF BALLAST..........

MEASUREMENTS OF AREA ABRADED

DATE OF MEASUREMENT	SQ. IN. ABRADED			
	LOW RAIL		HIGH RAIL	
	AREA ABRADED	DIFF.	AREA ABRADED	DIFF.

North & South Railroad

..........DIVISION

DIAGRAM SHOWING LINES OF WEAR

OF

..........RAIL,

LAID IN 19..........REMOVED IN 19..........

BETWEEN..........AND..........

SCALE FULL SIZE DATE..........

FORM 403C

North & South Railroad

STATEMENT OF COMPARATIVE WEAR OF TEST RAIL.

....192.......

TEST NO.	LOCATION	TAN OR DEGREE OF CURVE	MFR	WT. PER YARD	TYPE OF SECTION	KIND OF STEEL	NO. OF TONS LAID	CHEMICAL COMPOSITION AVE. OF ALL HEATS							PHYSICAL PROPERTIES AVE. OF ALL RAILS TESTED				BRINELL HARDNESS NO.	DATE LAID	DATE REMOVED IF NOT STILL IN TRACK	DATE OF LAST MEASUREMENT	LGTH. OF SERVICE AT TIME OF LAST MEAS. IN YRS	*TONNAGE OVER RAILS	PERCENT OF AREA OF HEAD ABRADED AVE.	AREA ABRADED IN SQ. IN. AVERAGE OF ALL SECTIONS TAKEN		
								CAR.	PHOS	MAN	SIL.	SUL	NI.	CHR.	TENSILE STRENGTH LBS. PER SQ. IN.	ELASTIC LIMIT LBS. PER SQ. IN.	ELONGATION % OF ORIG. LENGTH	REDUCTION OF AREA % OF ORIG. SEC.								TOTAL	PER YEAR OF SERVICE	PER 10 MILLION TONS
1																												
2																												
3																												
4																												
5																												
6																												
7																												
8																												
9																												
10																												
11																												
12																												
13																												
14																												
15																												
16																												
17																												
18																												
19																												
20																												
21																												
22																												
23																												
24																												
25																												
26																												
27																												
28																												
29																												
30																												

*"TONNAGE"=TOTAL TONS (INCLUDES LOCOMOTIVES AND CABOOSE CARS) OVER EXPERIMENT FROM DATE LAID TO DATE REMOVED, EXPRESSED IN UNITS OF 10,000 TONS

COMMITTEE V.

TRACK.

[1] DEFINITIONS.

Alinement.—The horizontal location of a railway with reference to curves and tangents.

Branch Line.—The secondary line or lines of a railway.

Curve, Simple.—An arc of the circumference of a circle.

Curve, Degree of.—The angle subtended at the center of a simple curve by a 100-foot chord.

Curve, Compound.—A continuous change in direction of alinement by means of two or more contiguous simple curves of different degrees having a common direction at their junction points.

Curve, Easement.—A curve whose degree varies either uniformly or in some definitely determined manner so as to give a gradual transition between a tangent and a simple curve, which it connects, or between two simple curves.

Curve, Reverse.—Two contiguous simple curves in opposite directions, with a common direction at their junction point.

Curve, Vertical.—A curve used to connect intersecting grade-lines.

Connecting Track.—Two turnouts with the track between the frogs arranged to form a continuous passage between one track and another intersecting or oblique track or another remote parallel track.

Crossover.—Two turnouts with the track between the frogs, arranged to form a continuous passage between two nearby and generally parallel tracks.

Crossover, Double.—A combination of two crossovers in opposite directions, which intersect between the parallel tracks.

Elevation (of Curves).—The vertical distance that the outer rail is raised above the inner rail, sometimes called Superelevation.

Fastenings.—Splice bars, bolts and spikes.

Fastenings, Auxiliary.—Nutlocks, tie-plates, rail braces and anti-creeping devices.

Frog.—A device used where two rails intersect to permit engines and trains on one rail to cross the other.

---

[1] Adopted, Vol. 5, 1904, pp. 527, 535, 541-560; Vol. 6, 1905, pp. 748, 749, 759-761; Vol. 10, Part 1, 1909, pp. 400, 461-463; Vol. 11, Part 2, 1910, pp. 942, 955; Vol. 16, 1915, pp. 728, 1144; Vol. 17, 1916, pp. 387, 905; Vol. 18, 1917, pp. 417, 1491.

FROG GUARD RAIL.—A rail or other device to guide the wheel flange so that it is kept clear of the point of the frog.

FROG NUMBER.—One-half the cotangent of one-half the frog angle, or the number of units of length in which the spread is one unit.

GAGE (a Tool).—A tool by which the gage of track is determined.

GAGE (of Track).—The distance between the heads of the rails measured at right angles thereto at a point ⅝-inch below the top of the rail.

GAGE, STANDARD.—The gage of 4 feet 8½ inches.

LEVEL.—The condition of the track in which the elevation of the rails transversely is equal.

LINE.—The condition of the track in regard to uniformity in direction over short distances on tangents, or uniformity in variation in direction over short distances on curves.

LINING TRACK.—Shifting the track laterally to conform to the established alinement.

MAIN LINE.—The principal line or lines of a railway.

MAIN TRACK.— The running track of a railway whereon the movement of trains is controlled by timetable, train order or block signal.

For multiple main track generally the southerly or easterly main track shall be designated as the first main track and the adjacent one as the second main track, etc.

OUT OF FACE (referring to Track Work).—Work that proceeds completely and continuously over a given piece of track as distinguished from work at disconnected points only.

SCISSORS CROSSOVER.—See "Crossover, Double."

SLIP SWITCH.—A combination of one or two pairs of turnouts and a crossing where each pair of turnouts has a common curved lead and stock rail and the end frogs of the crossing serve for the turnout.

SPIRAL (when used with respect to Track).—A form of easement curve in which the change of degree of curve is uniform throughout its length.

SPIRAL, TEN-CHORD.—An approximate spiral measured in ten equal chords and whose change of degree of curve is directly proportional to the length measured along the spiral by such chords.

SPUR.—A line of railway diverging from a main or branch line, and over which no regular train service is maintained.

SURFACE.—The condition of the track as to vertical evenness or smoothness over short distances.

Switch.—A device consisting of two movable rails, necessary connections and operating parts, designed to turn an engine or train from a track on which it is running to another track.

Tangent.—Any straight portion of a railway alinement.

Track.—Ties, rails and fastenings; with all parts in their proper relative positions.

Turnout.—A track device consisting of a switch and frog with connecting and operating parts and supporting ties by which engines and trains may be passed from one track to another. A turnout begins with the switch and ends with the switch ties, or with the frog where long ties are not used.

Wye.—A principal track and two connecting tracks arranged like the letter "Y," with the top closed, by means of which engines and trains may be turned.

[2] MAINTENANCE OF LINE.

(a) Tangents.

Tangents should be adjusted between summits and between curves; or by throwing curves to meet tangents; or by partially throwing curves and partially throwing tangents as may require the least work. Centers should be set with transit to secure accurate line.

(b) Curves; Use of Easement Curves.

Easement curves should be used with all curves requiring an elevation of 2 inches or more for the highest permissible speed.

The choice of easement curves should be governed by the ultimate speed possibilities, considering probable revision of the worst features of alinement, rather than by existing schedule speed.

With curves of 6 degrees and over, which are speed-limiting curves, easement curves should be not less than 240 feet long.

With speed-limiting curves of less than 6 degrees, easement curves should have lengths in feet of not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 inches.

With curves which are not likely to limit speed, easement curves should have lengths in feet of not less than thirty times the elevation in inches for the ultimate speed, nor less than two-thirds the ultimate speed in miles per hour times the elevation in inches.

---

[2] Adopted, Vol. 3, 1902, pp. 55, 56, 67-78; Vol. 5, 1904, pp. 527, 528, 535, 561, 562; Vol. 6, 1905, pp. 753, 754, 759-761; Vol. 10, Part 1, 1909, pp. 400, 429, 430, 461-463, 464; Vol. 12, Part 1, 1911, pp. 402, 447; Vol. 16, 1915, pp. 731, 1145.

Longer easement curves than the minimum lengths thus determined may be used to advantage and will be convenient sometimes, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration of the effect on cost. For minor curves an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost nor adversely affect the degree of curve. The minimum lengths should be used in all cases where greater lengths would adversely affect the degrees of main curves.

Curve elevations should be attained and run out uniformly over the full length of easement curves with no elevation on tangents and full elevation on circular curves.

Easement curves should be used between curves of different degrees, and change of elevation should be effected just as between curves and tangents.

Any form of easement curve is satisfactory:

(1) In which the rate of increase in degree of curve can readily be changed to suit particular cases so that the length of easement curve shall be the same as the distance in which the outer rail is raised from nothing to full elevation.

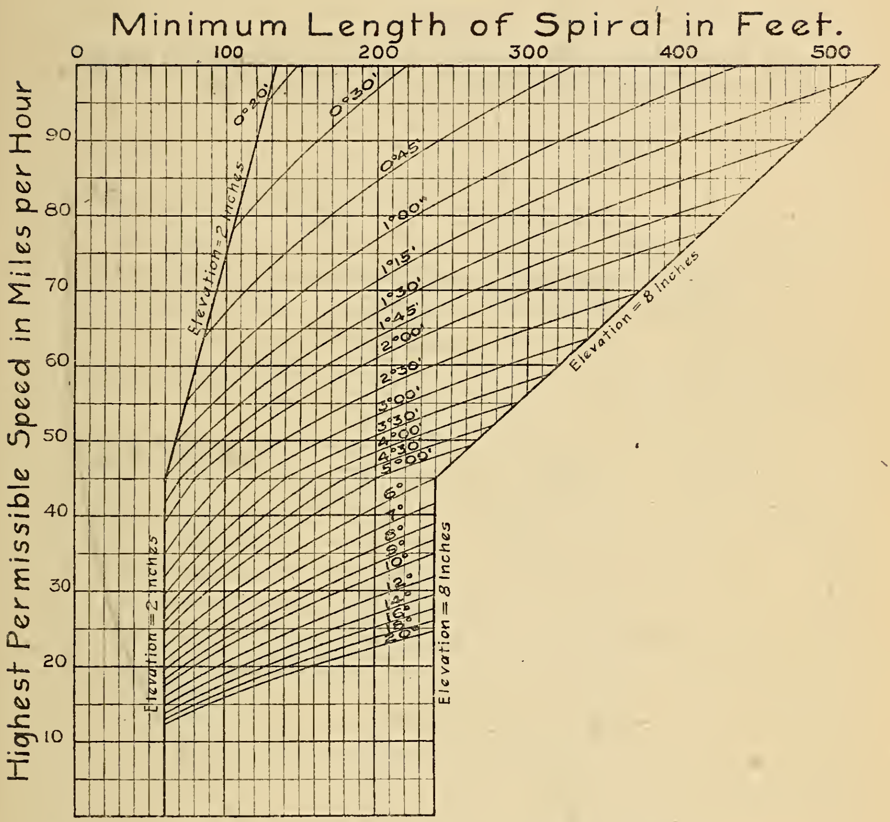
(2) Which can be run in by deflection or offset with chords of any desired length.

(3) Which is of the general type of either the Searles spiral, the cubic parabola, or the Holbrook, Crandall, Talbot, and 10-chord spiral.

The 10-chord spiral is recommended. Chords of any part of the spiral length may be used in staking out the 10-chord spiral when the central angle is small. To secure the most accurate results chords approximately one-tenth the length of spiral should be used when the central angle exceeds 15 degrees.

(c) Permanent Monuments.

Permanent monuments should be placed at points of tangent, points of spiral, points of change of curvature, summits, and at such other points along curves or tangents as will enable the alinement to be identically reproduced with a transit.



MINIMUM LENGTH OF EASEMENT CURVE.

Limiting Curves.

For all curves which are liable to limit the speed of trains, the length of spiral should equal that indicated on the line marked "Elevation = 8 inches." Longer spirals may be used provided the increased length does not adversely affect the degree of curve or seriously affect the cost of construction.

Minor Curves.

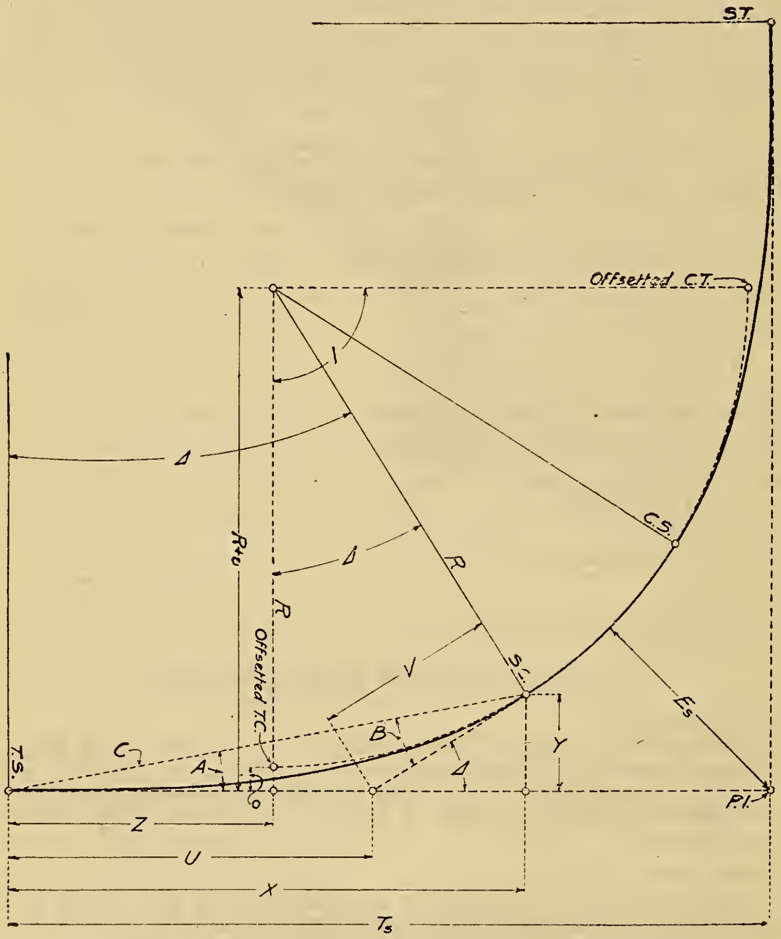
For minor curves the length of spiral should never be less than that indicated by the diagram; an increase of about 50 per cent. over the indicated length may be desirable where cost is not seriously affected.

Spirals need not be used when elevation required for highest permissible speed is less than two inches.

[3] SPIRALS.

NOTATION.

For curve points, the first initial represents the alinement on the side toward station zero, the second that away from station zero.



---

[3] Adopted, Vol. 12, Part 1, 1911, 418, 464; Vol. 16, 1915, pp. 731, 1145.

T. C.	The point of change in alinement from tangent to circular curve.
C. T.	The point of change from circular curve to tangent.
C. C.	The point of change in degree of circular curve; the point of compound curve, the point of reverse curve.
T. S.	The point of change from tangent to spiral.
S. C.	The point of change from spiral to circular curve.
C. S.	The point of change from circular curve to spiral.
S. T.	The point of change from spiral to tangent.
S. S.	The point of change from one spiral to another.

The symbols *T. C.* and *C. T.*, *T. S.* and *S. T.*, and *S. C.* and *C. S.* become transposed when the direction of stationing is changed.

a	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to any point on the spiral.
A	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to the *S. C.*
b	The angle at any point on the spiral, between the tangent at that point and the chord from the *T. S.*
B	The angle at the *S. C.* between the chord from the *T. S.* and the tangent at the *S. C.*
c	The chord from the *T. S.* to any point on the spiral.
C	The chord from the *T. S.* to the *S. C.*
d	The degree of curve at any point on the spiral.
D	The degree of central circular curve.
f	The angle between any chord of the spiral (produced if necessary) and the tangent through the *T. S.*
I	The angle between the initial and final tangents; the total central angle of circular curve and spirals.
k	The increase in degree of curve per station on the spiral.
l	The length of the spiral in feet from the *T. S.* to any given point.
L	The length of the spiral in feet from the *T. S.* to the *S. C.*
o	The ordinate of the offset *T. C.*; the distance between the tangent and a parallel tangent to the offset curve.
r	The radius of the osculating circle at any given point of the spiral.
R	The radius of the central circular curve.
s	The length of the spiral in stations from the *T. S.* to any given point.
S	The length of the spiral in stations from the *T. S.* to the *S. C.*
u	The distance on the tangent from the *T. S.* to the intersection with a tangent through any given point of the spiral.

U The distance on the tangent from the *T. S.* to the intersection with a tangent through the *S. C.*; the longer spiral tangent.

v The distance on the tangent through any given point from that point to the intersection with the tangent through the *T. S.*

V The distance on the tangent through the *S. C.* from the *S. C.* to the intersection with the tangent through the *T. S.*; the shorter spiral tangent.

x The abscissa or tangent distance of any given point, referred to the *T. S.*

X The abscissa or tangent distance of the *S. C.*, referred to the *T. S.*

y The ordinate or tangent offset of any point on the spiral.

Y The ordinate or tangent offset of the *S. C.*.

Z The abscissa or tangent distance of the offset *T. C.*, referred to the *T. S.*

δ The central angle of the spiral from the *T. S.* to any given point.

Δ The central angle of the whole spiral.

Ts The tangent distance of the spiraled curve; distance from *T. S.* to *P. I.* (point of intersection of tangents).

Es The external distance of the offset curve.

FORMULAS FOR THE EXACT DETERMINATION OF THE FUNCTIONS OF THE TEN-CHORD SPIRAL WHEN THE CENTRAL ANGLE DOES NOT EXCEED 45 DEGREES.

$$\left.\begin{aligned} d &= ks = \frac{kl}{100} \\ D &= kS = \frac{kL}{100} \end{aligned}\right\} \dots\dots\dots\dots (1)$$

$$\left.\begin{aligned} \delta &= \frac{ks^2}{2} = \frac{ds}{2} = \frac{kl^2}{20000} = \frac{dl}{200} \\ \Delta &= \frac{kS^2}{2} = \frac{DS}{2} = \frac{kL^2}{20000} = \frac{DL}{200} \end{aligned}\right\} \dots\dots\dots\dots (2)$$

$$A = \tfrac{1}{3}\Delta - 0.00297\,\Delta^3 \text{ seconds} \dots\dots\dots\dots (3)$$

$$B = \Delta - A \dots\dots\dots\dots (4)$$

$$C = L\,(\cos 0.3\,\Delta + .004 \operatorname{exsec} \tfrac{3}{4}\,\Delta) \dots\dots\dots\dots (5)$$

$$X = C \cos A \dots\dots\dots\dots (6)$$

$$Y = C \sin A \dots\dots\dots\dots (7)$$

$$U = C\,\frac{\sin B}{\sin \Delta} \dots\dots\dots\dots (8)$$

$$V = C\frac{\sin A}{\sin \Delta} \tag{9}$$

$$R = \frac{50}{\sin \frac{1}{2} D} \tag{10}$$

$$Z = X - R \sin \Delta \tag{11}$$

$$o = Y - R \operatorname{vers} \Delta \tag{12}$$

$$T_s = (R + o) \tan (\tfrac{1}{2} I) + Z \tag{13}$$

$$E = (R + o) \operatorname{exsec} (\tfrac{1}{2} I) + o \tag{14}$$

FORMULAS FOR FIELD USE.

The formulas presented above are best adapted for the preparation of tables. For use in the field, the following empirical formulas are sufficiently accurate and have the advantage that they do not require the computation of the long chord. The formulas can all be applied for the functions of any parts of the spiral without serious error, though they are derived for the completed spiral.

$$\left.\begin{array}{l} a = \frac{1}{3}\delta \\ A = \frac{1}{3}\Delta \end{array}\right\} \tag{15}$$

$$\left.\begin{array}{l} a = 10\, ks^2 \text{ minutes} \\ A = 10\, kS^2 \text{ minutes} \end{array}\right\} \tag{16}$$

Formulas (15) and (16) are sufficiently accurate for turning deflections when δ (or Δ) does not exceed 15 degrees.

A similar approximation may be used when the transit is set at an intermediate point on the spiral if the included central angle from the transit point to the point of sight, less the included angle from the *T. S.* to the transit point, does not exceed 15 degrees.

$$X = L - L\left(\tfrac{1}{3} \operatorname{vers} \tfrac{3}{4}\Delta + \tfrac{1}{22} \operatorname{vers} \tfrac{1}{2}\Delta\right) \tag{17}$$

$$Y = \frac{L}{39}\left(20 \sin \tfrac{1}{2}\Delta + 3 \sin \Delta\right) \tag{18}$$

$$U = L\left(\tfrac{2}{3} + \tfrac{10}{89} \operatorname{exsec} \tfrac{1}{2}\Delta + \tfrac{1}{10} \operatorname{vers} \tfrac{1}{4}\Delta\right) \tag{19}$$

$$V = L\left(\tfrac{1}{3} + \tfrac{10}{39} \operatorname{exsec} \tfrac{1}{2}\Delta\right) \tag{20}$$

$$o = \frac{L}{10}\left(\sin \tfrac{1}{2}\Delta + \sin \tfrac{1}{3}\Delta\right) \cos \tfrac{1}{2} D \tag{21}$$

$$Z = L\left(0.5 - .12885 \operatorname{vers} \tfrac{1}{2}\Delta\right) - .073\, D \sin \Delta \tag{22}$$

$$L = \frac{370.82}{\cos^{21/60} D}\left(1 + .000018\, Do\right)\sqrt{\frac{o}{D}} \tag{23}$$

STAKING SPIRALS BY OFFSETS.

The spiral may be staked by offsets, one-half being offset from the tangent and the other half from circular curve, by making the offsets vary directly as the cube of the distance from the *T. S.* and the *S. C.* This should be done either by using right angle and normal offsets, making the right angle or normal offset for the middle point of the spiral equal one-half *o;* or else by measuring half the total length of the spiral along the tangent, bisecting the distance to the offset *T. C.* for the offset to the middle point of spiral and using oblique offsets between equidistant points on the tangent or circular curve and equidistant points on the spiral.

Both methods will produce spirals somewhat at variance with any theoretical curve, but the variations are of no practical consequence.

If closer adherence to the theoretical curve is desired, the entire spiral may be staked from the tangent by use of the coördinate x and y.

STAKING SPIRALS BY DEFLECTIONS.

While any length of chord may be used in staking the spiral, either by offsets or deflections, the most accurate results are obtained by the use of ten equal chords, which is frequently the most convenient method when through-line stationing is not used.

If the spiral be divided into ten equal chords, the first deflection in minutes equals the degree of the main curve times the length of the chord in stations; *e. g.,* when $L = 500$ and $D = 4$, $s_1 = 0.5$ and $a_1 =$ d times $0.5 = 2$ minutes. The remaining deflections are as the squares of the chord numbers, or 4, 9, 16, etc., times the first deflection.

The same limitations apply to these deflections as well as deflections derived from the table of coefficients, as apply to the use of formulas (15) and (16).

When Δ exceeds 15 degrees, formula (3) should be used or else an additional transit point used between the *T. S.* and the *S. T.*

In the latter case the deflection angle from a tangent through a point P' to a point P'' is the deflection for the degree of curve at P' for the distance P' P'' plus or minus the initial spiral deflection angle for the distance P' P''.

This rule applies equally to spirals run in from any point on spiral, from the *S. T.*, or to a spiral connecting two circular curves, the latter being simply the requisite portion of the ordinary spiral. The rule is approximate and should not be used when the central angle from P' to P'' exceeds the central angle from the $T.\ S.$ to P' by more than 15 degrees.

The following table gives the coefficient by which the first chord deflection is to be multiplied to give the deflection to other chord points for various positions of the transit.

COEFFICIENTS OF a_1 FOR DEFLECTION ANGLES TO CHORD POINTS

Deflection Angle to Chord Point Number	Transit at Chord-Point Number										
	0 *T. S.*	1	2	3	4	5	6	7	8	9	10 *S.C.*
0 *T.S.*	0	2	8	18	32	50	72	98	128	162	200
1	1	0	5	14	27	44	65	90	119	152	189
2	4	4	0	8	20	36	56	80	108	140	176
3	9	10	7	0	11	26	45	68	95	126	161
4	16	18	16	10	0	14	32	54	80	110	144
5	25	28	27	22	13	0	17	38	63	92	125
6	36	40	40	36	28	16	0	20	44	72	104
7	49	54	55	52	45	34	19	0	23	50	81
8	64	70	72	70	64	54	40	22	0	26	56
9	81	88	91	90	85	76	63	46	25	0	29
10 *S.C.*	100	180	112	112	108	100	88	72	52	28	0

Table of Functions of the Ten-Chord Spiral.

The following table gives values of the deflection angle A for values of Δ varying by tenths of degrees, and for the same values of Δ it gives coefficients of L for obtaining the long chord C, the coördinates X and Y to the end of the spiral and the spiral tangents U and V; also coefficients of L and D for obtaining the coördinates of o and Z of the offset point of curve.

To obtain any desired quantity in feet, knowing D and choosing a proper value of L, or choosing a value of k which will give a proper value for L and determining L from formula (1), derive Δ from equation (2). Opposite Δ find the tabulated value of the coefficient for the desired quantity and multiply it by L. For o and Z apply the coefficients as indicated in the column heading.

Interpolate when necessary.

For the functions of any intermediate point on the spiral as x, y, etc., proceed exactly in the same manner as for the completed spiral.

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
0.0°	0° 00′ 00″	1.000 000	1.000 000	.000 000
0.1°	0° 02′ 00″	1.000 000	1.000 000	.000 582
0.2°	0° 04′ 00″	.999 999	.999 999	.001 164
0.3°	0° 06′ 00″	.999 999	.999 997	.001 745
0.4°	0° 08′ 00″	.999 998	.999 995	.002 327
0.5°	0° 10′ 00″	.999 997	.999 992	.002 909
0.6°	0° 12′ 00″	.999 995	.999 989	.003 491
0.7°	0° 14′ 00″	.999 993	.999 985	.004 072
0.8°	0° 16′ 00″	.999 991	.999 981	.004 654
0.9°	0° 18′ 00″	.999 989	.999 975	.005 236
1.0°	0° 20′ 00″	.999 987	.999 970	.005 818
1.1°	0° 22′ 00″	.999 984	.999 963	.006 399
1.2°	0° 24′ 00″	.999 981	.999 956	.006 981
1.3°	0° 26′ 00″	.999 977	.999 949	.007 563
1.4°	0° 28′ 00″	.999 974	.999 941	.008 145
1.5°	0° 30′ 00″	.999 970	.999 932	.008 726
1.6°	0° 32′ 00″	.999 966	.999 922	.009 308
1.7°	4° 34′ 00″	.999 961	.999 912	.009 890
1.8°	0° 36′ 00″	.999 957	.999 902	.010 471
1.9°	0° 38′ 00″	.999 952	.999 891	.011 053
2.0°	0° 40′ 00″	.999 947	.999 879	.011 635
2.1°	0° 42′ 00″	.999 941	.999 866	.012 216
2.2°	0° 44′ 00″	.999 935	.999 853	.012 798
2.3°	0° 46′ 00″	.999 929	.999 840	.013 379
2.4°	0° 48′ 00″	.999 923	.999 826	.013 961
2.5°	0° 50′ 00″	.999 916	.999 811	.014 542
2.6°	0° 52′ 00″	.999 910	.999 795	.015 124
2.7°	0° 54′ 00″	.999 903	.999 779	.015 706
2.8°	0° 56′ 00″	.999 895	.999 763	.016 287
2.9°	0° 58′ 00″	.999 888	.999 745	.016 868
3.0°	1° 00′ 00″	.999 880	.999 727	.017 450
3.1°	1° 02′ 00″	.999 872	.999 709	.018 031
3.2°	1° 04′ 00″	.999 863	.999 690	.018 613
3.3°	1° 06′ 00″	.999 854	.999 670	.019 194
3.4°	1° 08′ 00″	.999 846	.999 650	.019 775
3.5°	1° 10′ 00″	.999 836	.999 629	.020 357
3.6°	1° 12′ 00″	.999 827	.999 608	.020 938
3.7°	1° 14′ 00″	.999.817	.999 585	.021 519
3.8°	1° 16′ 00″	.999 807	.999 563	.022 101
3.9°	1° 18′ 00″	.999 797	.999 539	.022 682
4.0°	1° 20′ 00″	.999 786	.999 515	.023 263
4.1°	1° 22′ 00″	.999 775	.999 491	.023 844
4.2°	1° 24 00″	.999 764	.999 466	.024 425
4.3°	1° 26′ 00″	.999 753	.999 440	.025 006
4.4°	1° 28′ 00″	.999 741	.999 414	.025 588
4.5°	1° 30′ 00″	.999 729	.999 387	.026 169
4.6°	1° 32′ 00″	.999 717	.999 359	.026 750
4.7°	1° 34′ 00″	.999 705	.999 331	.027 331
4.8°	1° 36′ 00″	.999 692	.999 302	.027 911
4.9°	1° 38′ 00″	.999 679	.999 273	.028 492
5.0°	1° 40′ 00″	.999 666	.999 243	029 073

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.666 667	.333 333	.000 000	.000 00	.500 000	.000 00	0.0°
.666 667	.333 333	.000 145	.000 00	.500 000	.000 13	0.1°
.666 667	.333 334	.000 291	.000 00	.500 000	.000 25	0.2°
.666 668	.333 334	.000 436	.000 00	.500 000	.000 38	0.3°
.666 668	.333 335	.000 582	.000 00	.499 999	.000 51	0.4°
.666 669	.333 336	.000 727	.000 00	.499 999	.000 64	0.5°
.666 671	.333 337	.000 873	.000 00	.499 998	.000 76	0.6°
.666 672	.333 338	.001 018	.000 01	.499 998	.000 89	0.7°
.666 674	.333 340	.001 164	.000 01	.499 997	.001 02	0.8°
.666 675	.333 341	.001 309	.000 01	.499 996	.001 15	0.9°
.666 677	.333 343	.001 454	.000 01	.499 995	.001 27	1.0°
.666 680	.333 345	.001 600	.000 01	.499 994	.001 40	1.1°
.666 682	.333 347	.001 745	.000 02	.499 993	.001 53	1.2°
.666 685	.333 350	.001 891	.000 02	.499 992	.001 66	1.3°
.666 688	.333 352	.002 036	.000 02	.499 990	.001 78	1.4°
.666 691	.333 355	.002 182	.000 03	.499 989	.001 91	1.5°
.666 694	.333 358	.002 327	.000 03	.499 987	.002 04	1.6°
.666 698	.333 362	.002 472	.000 03	.499 986	.002 17	1.7°
.666 701	.333 365	.002 618	.000 04	.499 984	.002 29	1.8°
.666 705	.333 369	.002 763	.000 04	.499 982	.002 42	1.9°
.666 710	.333 372	.002 909	.000 04	.499 980	.002 55	2.0°
.666 714	.333 376	.003 054	.000 05	.499 978	.002 68	2.1°
.666 719	.333 381	.003 200	.000 05	.499 976	.002 80	2.2°
.666 723	.333 385	.003 345	.000 06	.499 974	.002 93	2.3°
.666 728	.333 390	.003 490	.000 06	.499 972	.003 06	2.4°
.666 734	.333 394	.003 636	.000 07	.499 969	.003 18	2.5°
.666 739	.333 399	.003 781	.000 08	.499 967	.003 31	2.6°
.666 745	.333 405	.003 927	.000 08	.499 964	.003 44	2.7°
.666 751	.333 410	.004 072	.000 09	.499 962	.003 57	2.8°
.666 757	.333 415	.004 218	.000 09	.499 959	.003 69	2.9°
.666 763	.333 421	.004 363	.000 10	.499 956	.003 82	3.0°
.666 770	.333 427	.004 508	.000 11	.499 953	.003 95	3.1°
.666 776	.333 433	.004 654	.000 11	.499 950	.004 07	3.2°
.666 783	.333 440	.004 799	.000 12	.499 947	.004 20	3.3°
.666 791	.333 446	.004 945	.000 13	.499 943	.004 33	3.4°
.666 798	.333 453	.005 090	.000 14	.499 940	.004 46	3.5°
.666 806	.333 460	.005 235	.000 14	.499 936	.004 58	3.6°
.666 813	.333 467	.005 381	.000 15	.499 933	.004 71	3.7°
.666 822	.333 474	.005 526	.000 16	.499 929	.004 84	3.8°
.666 830	.333 482	.005 671	.000 17	.499 925	.004 97	3.9°
.666 838	.333 490	.005 817	.000 18	.499 922	.005 09	4.0°
.666 847	.333 498	.005 962	.000 19	.499 918	.005 22	4.1°
.666 856	.333 506	.006 108	.000 20	.499 914	.005 35	4.2°
.666 865	.333 514	.006 253	.000 21	.499 909	.005 47	4.3°
.666 874	.333 522	.006 398	.000 22	.499 905	.005 60	4.4°
.666 884	.333 531	.006 544	.000 23	.499 901	.005 73	4.5°
.666 894	.333 540	.006 689	.000 24	.499 896	.005 85	4.6°
.666 904	.333 549	.006 834	.000 25	.499 892	.005 98	4.7°
.666 914	.333 558	.006 980	.000 26	.499 887	.006 11	4.8°
.666 924	.333 568	.007 125	.000 27	.499 882	.006 24	4.9°
.666 935	.333 578	.007 270	.000 28	.499 877	.006 36	5.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073
5.1°	1° 42′ 00″	.999 652	.999 212	.029 654
5.2°	1° 44′ 00″	.999 639	.999 181	.030 235
5.3°	1° 46′ 00″	.999 625	.999 150	.030 816
5.4°	1° 48′ 00″	.999 610	.999 117	.031 396
5.5°	1° 50′ 00″	.999 596	.999 084	.031 977
5.6°	1° 51′ 59″	.999 581	.999 051	.032 558
5.7°	1° 53′ 59″	.999 566	.999 016	.033 138
5.8°	1° 55′ 59″	.999 550	.998 982	.033 719
5.9°	1° 57′ 59″	.999 535	.998 946	.034 299
6.0°	1° 59′ 59″	.999 519	.998 910	.034 880
6.1°	2° 01′ 59″	.999 503	.998 874	.035 460
6.2°	2° 03′ 59″	.999 486	.998 836	.036 040
6.3°	2° 05′ 59″	.999 470	.998 799	.036 621
6.4°	2° 07′ 59″	.999 453	.998 760	.037 201
6.5°	2° 09′ 59″	.999 435	.998 721	.037 781
6.6°	2° 11′ 59″	.999 418	.998 681	.038 361
6.7°	2° 13′ 59″	.999 400	.998 641	.038 941
6.8°	2° 15′ 59″	.999 382	.998 600	.039 522
6.9°	2° 17′ 59″	.999 364	.998 559	.040 102
7.0°	2° 19′ 59″	.999 345	.998 517	.040 682
7.1°	2° 21′ 59″	.999 326	.998 474	.041 261
7.2°	2° 23′ 59″	.999 307	.998 431	.041 841
7.3°	2° 25′ 59″	.999 288	.998 387	.042 421
7.4°	2° 27′ 59″	.999 268	.998 343	.043 001
7.5°	2° 29′ 59″	.999 248	.998 298	.043 581
7.6°	2° 31′ 59″	.999 228	.998 252	.044 160
7.7°	2° 33′ 59″	.999 208	.998 206	.044 740
7.8°	2° 35′ 59″	.999 187	.998 159	.045 319
7.9°	2° 37′ 59″	.999 166	.998 111	.045 899
8.0°	2° 39′ 58″	.999 145	.998 063	.046 478
8.1°	2° 41′ 58″	.999 123	.998 015	.047 058
8.2°	2° 43′ 58″	.999 102	.997 965	.047 637
8.3°	2° 45′ 58″	.999 080	.997 915	.048 216
8.4°	2° 47′ 58″	.999 057	.997 865	.048 795
8.5°	2° 49′ 58″	.999 035	.997 814	.049 374
8.6°	2° 51′ 58″	.999 012	.997 762	.049 953
8.7°	2° 53′ 58″	.998 989	.997 710	.050 532
8.8°	2° 55′ 58″	.998 965	.997 657	.051 111
8.9°	2° 57′ 58″	.998 942	.997 603	.051 690
9.0°	2° 59′ 58″	.998 918	.997 549	.052 269
9.1°	3° 01′ 58″	.998 894	.997 495	.052 848
9.2°	3° 03′ 58″	.998 869	.997 439	.053 426
9.3°	3° 05′ 58	.998 844	.997 383	.054 005
9.4°	3° 07′ 58″	.998 819	.997 327	.054 583
9.5°	3° 09′ 57″	.998 794	.997 270	.055 162
9.6°	3° 11′ 57″	.998 769	.997 212	.055 740
9.7°	3° 13′ 57″	.998 743	.997 154	.056 318
9.8°	3° 15′ 57″	.998 717	.997 095	.056 897
9.9°	3° 17′ 57″	.998 691	.997 035	.057 475
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.666 935	.333 578	.007 270	.000 28	.499 877	.006 36	5.0°
.666 946	.333 587	.007 416	.000 29	.499 872	.006 49	5.1°
.666 957	.333 598	.007 561	.000 30	.499 867	.006 62	5.2°
.666 968	.333 608	.007 706	.000 31	.499 862	.006 74	5.3°
.666 979	.333 618	.007 852	.000 32	.499 857	.006 87	5.4°
.666 991	.333 629	.007 997	.000 34	.499 852	.007 00	5.5°
.667 003	.333 640	.008 142	.000 35	.499 846	.007 12	5.6°
.667 015	.333 651	.008 288	.000 36	.499 841	.007 25	5.7°
.667 028	.333 662	.008 433	.000 37	.499 835	.007 38	5.8°
.667 040	.333 674	.008 578	.000 39	.499 829	.007 50	5.9°
.667 053	.333 685	.008 724	.000 40	.499 824	.007 63	6.0°
.667 066	.333 697	.008 869	.000 41	.499 818	.007 76	6.1°
.667 079	.333 709	.009 014	.000 43	.499 812	.007 88	6.2°
.667 093	.333 721	.009 159	.000 44	.499 805	.008 01	6.3°
.667 106	.333 734	.009 305	.000 45	.499 799	.008 14	6.4°
.667 120	.333 746	.009 450	.000 47	.499 793	.008 26	6.5°
.667 134	.333 759	.009 595	.000 48	.499 786	.008 39	6.6°
.667 148	.333 772	.009 740	.000 50	.499 780	.008 52	6.7°
.667 163	.333 785	.009 886	.000 51	.499 773	.008 64	6.8°
.667 178	.333 799	.010 031	.000 53	.499 767	.008 77	6.9°
.667 193	.333 812	.010 176	.000 54	.499 760	.008 90	7.0°
.667 208	.333 826	.010 321	.000 56	.499 753	.009 02	7.1°
.667 223	.333 840	.010 467	.000 58	.499 746	.009 15	7.2°
.667 239	.333 854	.010 612	.000 59	.499 739	.009 28	7.3°
.667 255	.333 869	.010 757	.000 61	.499 732	.009 40	7.4°
.667 271	.333 883	.010 902	.000 62	.499 724	.009 53	7.5°
.667 287	.333 898	.011 048	.000 64	.499 717	.009 65	7.6°
.667 303	.333 913	.011 193	.000 66	.499 709	.009 78	7.7°
.667 320	.333 928	.011 338	.000 68	.499 702	.009 91	7.8°
.667 337	.333 944	.011 483	.000 69	.499 694	.010 03	7.9°
.667 354	.333 959	.011 628	.000 71	.499 686	.010 16	8.0°
.667 371	.333 975	.011 773	.000 73	.499 678	.010 29	8.1°
.667 389	.333 991	.011 919	.000 75	.499 670	.010 41	8.2°
.667 407	.334 007	.012 064	.000 76	.499 662	.010 54	8.3°
.667 424	.334 024	.012 209	.000 78	.499 654	.010 66	8.4°
.667 443	.334 040	.012 354	.000 80	.499 646	.010 79	8.5°
.667 461	.334 057	.012 499	.000 82	.499 637	.010 92	8.6°
.667 480	.334 074	.012 644	.000 84	.499 629	.011 04	8.7°
.667 499	.334 091	.012 789	.000 86	.499 620	.011 17	8.8°
.667 518	.334 109	.012 935	.000 88	.499 612	.011 29	8.9°
.667 537	.334 126	.013 080	.000 90	.499 603	.011 42	9.0°
.667 556	.334 144	.013 225	.000 92	.499 594	.011 55	9.1°
.667 576	.334 162	.013 370	.000 94	.499 585	.011 67	9.2°
.667 596	.334 180	.013 515	.000 96	.499 576	.011 80	9.3°
.667 616	.334 198	.013 660	.000 98	.499 567	.011 92	9.4°
.667 636	.334 217	.013 805	.001 00	.499 558	.012 05	9.5°
.667 657	.334 236	.013 950	.001 02	.499 548	.012 17	9.6°
.667 678	.334 255	.014 095	.001 04	.499 539	.012 30	9.7°
.667 699	.334 274	.014 240	.001 07	.499 529	.012 43	9.8°
.667 720	.334 293	.014 385	.001 09	.499 520	.012 55	9.9°
.667 742	.334 313	.014 530	.001 11	.499 510	.012 68	10.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

△	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053
10.1°	3° 21′ 57″	.998 637	.996 915	.058 631
10.2°	3° 23′ 57″	.998 610	.996 853	.059 209
10.3°	3° 25′ 57″	.998 583	.996 791	.059 787
10.4°	3° 27′ 57″	.998 555	.996 729	.060 364
10.5°	3° 29′ 57″	.998 527	.996 666	.060 942
10.6°	3° 31′ 56″	.998 499	.996 602	.061 520
10.7°	3° 33′ 56″	.998 471	.996 538	.062 097
10.8°	3° 35′ 56″	.998 442	.996 473	.062 675
10.9°	3° 37′ 56″	.998 413	.996 407	.063 252
11.0°	3° 39′ 56″	.998 384	.996 341	.063 829
11.1°	3° 41′ 56″	.998 354	.996 274	.064 406
11.2°	3° 43′ 56″	.998 324	.996 207	.064 984
11.3°	3° 45′ 56″	.998 294	.996 139	.065 561
11.4°	3° 47′ 56″	.998 264	.996 071	.066 138
11.5°	3° 49′ 55″	.998 233	.996 002	.066 714
11.6°	3° 51 55″	.998 203	.995 932	.067 291
11.7°	3° 53′ 55″	.998 171	.995 862	.067 868
11.8°	3° 55′ 55″	.998 140	.995 791	.068 445
11.9°	3° 57′ 55″	.998 108	.995 719	.069 021
12.0°	3° 59′ 55″	.998 077	.995 647	.069 598
12.1°	4° 01′ 55″	998 044	.995 574	.070 174
12.2°	4° 03′ 55″	.998 012	.995 501	.070 750
12.3°	4° 05′ 54″	.997 979	.995 427	.071 326
12.4°	4° 07′ 54″	.997 946	.995 353	.071 902
12.5°	4° 09′ 54″	.997 913	.995 278	.072 478
12.6°	4° 11′ 54″	.997 880	.995 202	.073 054
12.7°	4° 13′ 54″	.997 846	.995 126	.073 630
12.8°	4° 15′ 54″	.997 812	.995 049	.074 206
12.9°	4° 17′ 54″	.997 777	.994 971	.074 781
13.0°	4° 19′ 53″	.997 743	.994 893	.075 357
13.1°	4° 21′ 53″	.997 708	.994 814	.075 932
13.2°	4° 23′ 53″	.997 673	.994 735	.076 508
13.3°	4° 25′ 53″	.997 638	.994 655	.077 083
13.4°	4° 27′ 53″	.997 602	.994 575	.077 658
13.5°	4° 29′ 53″	.997 566	.994 494	.078 233
13.6°	4° 31′ 53″	.997 530	.994 412	.078 808
13.7°	4° 33′ 52″	.997 493	.994 330	.079 383
13.8°	4° 35′ 52″	.997 457	.994 247	.079 957
13.9°	4° 37′ 52	.997 420	.994 163	.080 532
14.0°	4° 39′ 52″	.997 383	.994 079	.081 106
14.1°	4° 41′ 52″	.997 345	.993 995	.081 681
14.2°	4° 43′ 51″	.997 307	.993 909	.082 255
14.3°	4° 45′ 51″	.997 269	.993 824	.082 829
14.4°	4° 47′ 51″	.997 231	.993 737	.083 403
14.5°	4° 49′ 51″	.997 192	.993 650	.083 977
14.6°	4° 51′ 51″	.997 154	.993 563	.084 551
14.7°	4° 53′ 51″	.997 115	.993 474	.085 125
14.8°	4° 55′ 50″	.997 075	.993 385	.085 699
14.9°	4° 57′ 50″	.997 036	.993 296	.086 272
15.0°	4° 59′ 50″	996 996	.993 206	.086 846

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.667 742	.334 313	.014 530	.001 11	.499 510	.012 68	10.0°
.667 763	.334 332	.014 675	.001 13	.499 500	.012 80	10.1°
.667 785	.334 352	.014 820	.001 15	.499 490	.012 93	10.2°
.667 807	.334 373	.014 965	.001 18	.499 480	.013 05	10.3°
.667 830	.334 393	.015 110	.001 20	.499 470	.013 18	10.4°
.667 852	.334 413	.015 255	.001 22	.499 460	.013 30	10.5°
.667 875	.334 434	.015 400	.001 25	.499 449	.013 43	10.6°
.667 898	.334 455	.015 545	.001 27	.499 439	.013 55	10.7°
.667 921	.334 476	.015 690	.001 29	.499 428	.013 68	10.8°
.667 944	.334 498	.015 835	.001 32	.499 418	.013 80	10.9°
.667 968	.334 519	.015 980	.001 34	.499 407	.013 93	11.0°
.667 992	.334 541	.016 125	.001 37	.499 396	.014 05	11.1°
.668 016	.334 563	.016 270	.001 39	.499 385	.014 18	11.2°
.668 040	.334 585	.016 415	.001 42	.499 374	.014 30	11.3°
.668 065	.334 607	.016 560	.001 44	.499 363	.014 43	11.4°
.668 089	.334 630	.016 704	.001 47	.499 352	.014 55	11.5°
.668 114	.334 653	.016 849	.001 49	.499 341	.014 68	11.6°
.668 140	.334 676	.016 994	.001 52	.499 329	.014 80	11.7°
.668 165	.334 699	.017 139	.001 54	.499 318	.014 93	11.8°
.668 191	.334 722	.017 284	.001 57	.499 306	.015 05	11.9°
.668 216	.334 746	.017 429	.001 60	.499 294	.015 18	12.0°
.668 242	.334 769	.017 574	.001 62	.499 283	.015 30	12.1°
.668 269	.334 793	.017 718	.001 65	.499 271	.015 43	12.2°
.668 295	.334 817	.017 863	.001 68	.499 259	.015 55	12.3°
.668 322	.334 842	.018 008	.001 70	.499 247	.015 68	12.4°
.668 349	.334 866	.018 153	.001 73	.499 234	.015 80	12.5°
.668 376	.334 891	.018 298	.001 76	.499 222	.015 92	12.6°
.668 403	.334 916	.018 442	.001 79	.499 210	.016 05	12.7°
.668 431	.334 941	.018 587	.001 81	.499 197	.016 17	12.8°
.668 459	.334 967	.018 732	.001 84	.499 185	.016 30	12.9°
.668 487	.334 992	.018 877	.001 87	.499 172	.016 42	13.0°
.668 515	.335 018	.019 021	.001 90	.499 159	.016 55	13.1°
.668 543	.335 044	.019 166	.001 93	.499 146	.016 67	13.2°
.668 572	.335 070	.019 311	.001 96	.499 133	.016 79	13.3°
.668 601	.335 096	.019 455	.001 99	.499 120	.016 92	13.4°
.668 630	.335 123	.019 600	.002 02	.499 107	.017 04	13.5°
.668 660	.335 150	.019 745	.002 05	.499 094	.017 17	13.6°
.668 689	.335 177	.019 889	.002 08	.499 081	.017 29	13.7°
.668 719	.335 204	.020 034	.002 11	.499 067	.017 41	13.8°
.668 749	.335 231	.020 179	.002 14	.499 054	.017 54	13.9°
.668 779	.335 259	.020 323	.002 17	.499 040	.017 66	14.0°
.668 810	.335 287	.020 468	.002 20	.499 026	.017 78	14.1°
.668 840	.335 315	.020 612	.002 23	.499 012	.017 91	14.2°
.668 871	.335 343	.020 757	.002 26	.498 998	.018 03	14.3°
.668 902	.335 371	.020 902	.002 29	.498 984	.018 15	14.4°
.668 934	.335 400	.021 046	.002 33	.498 970	.018 28	14.5°
.668 965	.335 429	.021 191	.002 36	.498 956	.018 40	14.6°
.668 997	.335 458	.021 335	.002 39	.498 942	.018 52	14.7°
.669 029	.335 487	.021 480	.002 42	.498 927	.018 65	14.8°
.669 061	.335 516	.021 624	.002 45	.498 913	.018 77	14.9°
.669 094	.335 546	.021 769	.002 49	.498 898	.018 89	15.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
15.0°	4° 59′ 50″	.996 996	.993 206	.086 846
15.1°	5° 01′ 50″	.996 956	.993 115	.087 419
15.2°	5° 03′ 50″	.996 915	.993 024	.087 992
15.3°	5° 05′ 49″	.996 874	.992 932	.088 565
15.4°	5° 07′ 49″	.996 833	.992 840	.089 138
15.5°	5° 09′ 49″	.996 792	.992 747	.089 711
15.6°	5° 11′ 49″	.996 751	.992 654	.090 284
15.7°	5° 13′ 49″	.996 709	.992 559	.090 856
15.8°	5° 15′ 48″	.996 667	.992 465	.091 429
15.9°	5° 17′ 48″	.996 625	.992 369	.092 001
16.0°	5° 19′ 48″	.996 582	.992 273	.092 574
16.1°	5° 21′ 48″	.996 539	.992 177	.093 146
16.2°	5° 23′ 47″	.996 496	.992 080	.093 718
16.3°	5° 25′ 47″	.996 453	.991 982	.094 290
16.4°	5° 27′ 47″	.996 409	.991 884	.094 862
16.5°	5° 29′ 47″	.996 366	.991 785	.095 433
16.6°	5° 31′ 46″	.996 321	.991 685	.096 005
16.7°	5° 33′ 46″	.996 277	.991 585	.096 576
16.8°	5° 35′ 46″	.996 232	.991 484	.097 148
16.9°	5° 37′ 46″	.996 187	.991 383	.097 719
17.0°	5° 39′ 45″	.996 142	.991 281	.098 290
17.1°	5° 41′ 45″	.996 097	.991 179	.098 861
17.2°	5° 43′ 45″	.996 051	.991 076	.099 432
17.3°	5° 45′ 45″	.996 005	.990 972	.100 002
17.4°	5° 47′ 44″	.995 959	.990 868	.100 573
17.5°	5° 49′ 44″	.995 912	.990 763	.101 143
17.6°	5° 51′ 44″	.995 865	.990 658	.101 713
17.7°	5° 53′ 44″	.995 818	.990 552	.102 284
17.8°	5° 55′ 43″	.995 771	.990 445	.102 854
17.9°	5° 57′ 43″	.995 723	.990 338	.103 424
18.0°	5° 59′ 43″	.995 676	.990 230	.103 993
18.1°	6° 01′ 42″	.995 628	.990 122	.104 563
18.2°	6° 03′ 42″	.995 579	.990 013	.105 132
18.3°	6° 05′ 42″	.995 530	.989 903	.105 702
18.4°	6° 07′ 42″	.995 482	.989 793	.106 271
18.5°	6° 09 41″	.995 432	.989 682	.106 840
18.6°	6° 11′ 41″	.995 383	.989 571	107 409
18.7°	6° 13′ 41″	.995 333	.989 459	.107 978
18.8°	6° 15′ 40″	.995 283	.989 347	.108 547
18.9°	6° 17′ 40″	.995 233	.989 233	.109 115
19.0°	6° 19′ 40″	.995 183	.989 120	.109 683
19.1°	6° 21′ 39″	.995 132	.989 005	.110 252
19.2°	6° 23′ 39″	.995 081	.988 891	.110 820
19.3°	6° 25′ 39″	.995 029	.988 775	.111 388
19.4°	6° 27′ 38″	.994 978	.988 659	.111 956
19.5°	6° 29′ 38″	.994 926	.988 543	.112 523
19.6°	6° 31′ 38″	.994 874	.988 425	.113 091
19.7°	6° 33′ 37″	.994 822	.988 308	.113 658
19.8°	6° 35′ 37″	.994 769	.988 189	.114 225
19.9°	6° 37′ 37″	.994 716	.988 070	.114 793
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.669 094	.335 546	.021 769	.002 49	.498 898	.018 89	15.0°
.669 126	.335 576	.021 913	.002 52	.498 883	.019 02	15.1°
.669 159	.335 606	.022 058	.002 55	.498 869	.019 14	15.2°
.669 192	.335 636	.022 202	.002 59	.498 854	.019 26	15.3°
.669 226	.335 666	.022 347	.002 62	.498 839	.019 39	15.4°
.669 259	.335 697	.022 491	.002 65	.498 824	.019 51	15.5°
.669 293	.335 728	.022 635	.002 69	.498 808	.019 63	15.6°
.669 327	.335 759	.022 780	.002 72	.498 793	.019 75	15.7°
.669 361	.335 790	.022 924	.002 76	.498 778	.019 88	15.8°
.669 396	.335 821	.023 069	.002 79	.498 762	.020 00	15.9°
.669 431	.335 853	.023 213	.002 83	.498 747	.020 12	16.0°
.669 465	.335 885	.023 357	.002 86	.498 731	.020 24	16.1°
.669 501	.335 917	.023 502	.002 90	.498 715	.020 37	16.2°
.669 536	.335 949	.023 646	.002 93	.498 699	.020 49	16.3°
.669 572	.335 982	.023 790	.002 97	.498 683	.020 61	16.4°
.669 607	.336 014	.023 935	.003 01	.498 667	.020 73	16.5°
.669 643	.336 047	.024 079	.003 04	.498 651	.020 86	16.6°
.669 680	.336 080	.024 223	.003 08	.498 635	.020 98	16.7°
.669 716	.336 114	.024 367	.003 12	.498 618	.021 10	16.8°
.669 753	.336 147	.024 512	.003 15	.498 602	.021 22	16.9°
.669 790	.336 181	.024 656	.003 19	.498 585	.021 34	17.0°
.669 827	.336 215	.024 800	.003 23	.498 569	.021 46	17.1°
.669 864	.336 249	.024 944	.003 26	.498 552	.021 59	17.2°
.669 902	.336 283	.025 088	.003 30	.498 535	.021 71	17.3°
.669 940	.336 318	.025 233	.003 34	.498 518	.021 83	17.4°
.669 978	.336 353	.025 377	.003 38	.498 501	.021 95	17.5°
.670 016	.336 388	.025 521	.003 42	.498 484	.022 07	17.6°
.670 055	.336 423	.025 665	.003 46	.498 466	.022 19	17.7°
.670 093	.336 458	.025 809	.003 49	.498 449	.022 32	17.8°
.670 132	.336 494	.025 953	.003 53	.498 432	.022 44	17.9°
.670 172	.336 529	.026 097	.003 57	.498 414	.022 56	18.0°
.670 211	.336 565	.026 241	.003 61	.498 397	.022 68	18.1°
.670 251	.336 602	.026 385	.003 65	.498 379	.022 80	18.2°
.670 290	.336 638	.026 529	.003 69	.498 361	.022 92	18.3°
.670 331	.336 675	.026 673	.003 73	.498 343	.023 04	18.4°
.670 371	.336 711	.026 817	.003 77	.498 325	.023 16	18.5°
.670 411	.336 748	.026 961	.003 81	.498 307	.023 28	18.6°
.670 452	.336 786	.027 105	.003 85	.498 289	.023 40	18.7°
.670 493	.336 823	.027 249	.003 89	.498 270	.023 53	18.8°
.670 534	.336 861	.027 393	.003 94	.498 252	.023 65	18.9°
.670 576	.336 899	.027 537	.003 98	.498 233	.023 77	19.0°
.670 618	.336 937	.027 681	.004 02	.498 215	.023 89	19.1°
.670 660	.336 975	.027 825	.004 06	.498 196	.024 01	19.2°
.670 702	.337 013	.027 969	.004 10	.498 177	.024 13	19.3°
.670 744	.337 052	.028 113	.004 14	.498 158	.024 25	19.4°
.670 787	.337 091	.028 257	.004 19	.498 139	.024 37	19.5°
.670 829	.337 130	.028 400	.004 23	.498 120	.024 49	19.6°
.670 873	.337 169	.028 544	.004 27	.498 101	.024 61	19.7°
.670 916	.337 209	.028 688	.004 32	.498 082	.024 73	19.8°
.670 959	.337 249	.028 832	.004 36	.498 062	.024 85	19.9°
.671 003	.337 289	.028 976	.004 40	.498 043	.024 97	20.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360
20.1°	6° 41′ 36″	.994 610	.987 831	.115 926
20.2°	6° 43 36°	.994 556	.987 710	.116 493
20.3°	6° 45′ 35″	.994 502	.987 589	.117 060
20.4°	6° 47′ 35″	.994 448	.987 467	.117 626
20.5°	6° 49′ 34″	.994 393	.987 344	.118 192
20.6°	6° 51′ 34″	.994 339	.987 221	.118 758
20.7°	6° 53′ 34″	.994 284	.987 098	.119 324
20.8°	6° 55′ 33″	.994 228	.986 973	.119 890
20.9°	6° 57′ 33″	.994 173	.986 849	.120 455
21.0°	6° 59′ 32″	.994 117	.986 723	.121 021
21.1°	7° 01′ 32″	.994 061	.986 597	.121 586
21.2°	7° 03′ 32″	.994 005	.986 471	.122 151
21.3°	7° 05′ 31″	.993 948	.986 343	.122 716
21.4°	7° 07′ 31″	.993 891	.986 216	.123 281
21.5°	7° 09′ 30″	.993 834	.986 087	.123 846
21.6°	7° 11′ 30″	.993 777	.985 959	.124 410
21.7°	7° 13′ 30″	.993 719	.985 829	.124 975
21.8°	7° 15′ 29″	.993 661	.985 699	.125 539
21.9°	7° 17′ 29″	.993 603	.985 568	.126 103
22.0°	7° 19′ 28″	.993 545	.985 437	.126 667
22.1°	7° 21′ 28″	.993 486	.985 305	.127 230
22.2°	7° 23′ 28″	.993 427	.985 173	.127 794
22.3°	7° 25′ 27″	.993 368	.985 040	.128 357
22.4°	7° 27′ 27″	.993 308	.984 906	.128 920
22.5°	7° 29′ 26″	.993 248	.984 772	.129 483
22.6°	7° 31′ 26″	993 188	.984 638	.130 046
22.7°	7° 33′ 25″	.993 128	.984 502	.130 609
22.8°	7° 35′ 25″	.993 068	.984 366	.131 172
22.9°	7° 37′ 24″	.993 007	.984 230	.131 734
23.0°	7° 39′ 24″	.992 946	.984 093	.132 296
23.1°	7° 41′ 23″	.992 884	.983 955	.132 858
23.2°	7° 43′ 23″	.992 823	.983 817	.133 420
23.3°	7° 45′ 22″	.992 761	.983 678	.133 982
23.4°	7° 47′ 22″	.992 699	.983 539	.134 543
23.5°	7° 49′ 21″	.992 636	.983 399	.135 105
23.6°	7° 51′ 21″	.992 574	.983 259	.135 666
23.7°	7° 53′ 20″	.992 511	.983 118	.136 227
23.8°	7° 55′ 20″	.992 448	.982 976	.136 788
23.9°	7° 57′ 19″	.992 384	.982 834	.137 348
24.0°	7° 59′ 19″	.992 321	.982 691	.137 909
24.1°	8° 01′ 18″	.992 257	.982 547	.138 469
24.2°	8° 03′ 18″	.992 192	.982 403	.139 029
24.3°	8° 05′ 17″	.992 128	.982 259	.139 589
24.4°	8° 07′ 17″	.992 063	.982 114	.140 149
24.5°	8° 09′ 16″	.991 998	.981 968	.140 708
24.6°	8° 11′ 16″	.991 933	.981 822	.141 268
24.7°	8° 13′ 15″	.991 867	.981 675	.141 827
24.8°	8° 15′ 15″	.991 801	.981 528	.142 386
24.9°	8° 17′ 14″	.991 735	.981 380	.142 945
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

U/L	V/L	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.671 003	.337 289	.028 976	.004 40	.498 043	.024 97	20.0°
.671 047	.337 329	.029 119	.004 45	.498 023	.025 09	20.1°
.671 091	.337 369	.029 263	.004 49	.498 004	.025 21	20.2°
.671 136	.337 410	.029 407	.004 53	.497 984	.025 33	20.3°
.671 180	.337 451	.029 550	.004 58	.497 964	.025 45	20.4°
.671 225	.337 492	.029 694	.004 62	.497 944	.025 57	20.5°
.671 270	.337 533	.029 838	.004 67	.497 924	.025 68	20.6°
.671 316	.337 574	.029 981	.004 71	.497 904	.025 80	20.7°
.671 361	.337 616	.030 125	.004 76	.497 884	.025 92	20.8°
.671 407	.337 658	.030 269	.004 80	.497 863	.026 04	20.9°
.671 453	.337 700	.030 412	.004 85	.497 843	.026 16	21.0°
.671 499	.337 742	.030 556	.004 89	.497 822	.026 28	21.1°
.671 546	.337 785	.030 699	.004 94	.497 802	.026 40	21.2°
.671 593	.337 827	.030 843	.004 99	.497 781	.026 52	21.3°
.671 640	.337 870	.030 986	.005 03	.497 760	.026 64	21.4°
.671 687	.337 913	.031 130	.005 08	.497 739	.026 75	21.5°
.671 734	.337 957	.031 273	.005 13	.497 718	.026 87	21.6°
.671 782	.338 000	.031 417	.005 17	.497 697	.026 99	21.7°
.671 830	.338 044	.031 560	.005 22	.497 676	.027 11	21.8°
.671 878	.338 088	.031 704	.005 27	.497 655	.027 23	21.9°
.671 926	.338 132	.031 847	.005 32	.497 633	.027 35	22.0°
.671 975	.338 177	.031 990	.005 36	.497 612	.027 46	22.1°
.672 024	.338 221	.032 134	.005 41	.497 590	.027 58	22.2°
.672 073	.338 266	.032 277	.005 46	.497 568	.027 70	22.3°
.672 122	.338 311	.032 421	.005 51	.497 547	.027 82	22.4°
.672 172	.338 356	.032 564	.005 56	.497 525	.027 94	22.5°
.672 221	.338 402	.032 707	.005 61	.497 503	.028 05	22.6°
.672 271	.338 448	.032 850	.005 65	.497 481	.028 17	22.7°
.672 322	.338 494	.032 994	.005 70	.497 458	.028 29	22.8°
.672 372	.338 540	.033 137	.005 75	.497 436	.028 41	22.9°
.672 423	.338 586	.033 280	.005 80	.497 414	.028 52	23.0°
.672 474	.338 633	.033 423	.005 85	.497 391	.028 64	23.1°
.672 525	.338 679	.033 567	.005 90	.497 369	.028 76	23.2°
.672 576	.338 726	.033 710	.005 95	.497 346	.028 87	23.3°
.672 628	.338 774	.033 853	.006 00	.497 323	.028 99	23.4°
.672 680	.338 821	.033 996	.006 05	.497 300	.029 11	23.5°
.672 732	.338 869	.034 139	.006 11	.497 277	.029 23	23.6°
.672 784	.338 917	.034 282	.006 16	.497 254	.029 34	23.7°
.672 837	.338 965	.034 425	.006 21	.497 231	.029 46	23.8°
.672 890	.339 013	.034 568	.006 26	.497 208	.029 58	23.9°
.672 943	.339 061	.034 711	.006 31	.497 185	.029 69	24.0°
.672 996	.339 110	.034 854	.006 36	.497 161	.029 81	24.1°
.673 050	.339 159	.034 997	.006 42	.497 138	.029 92	24.2°
.673 103	.339 208	.035 140	.006 47	.497 114	.030 04	24.3°
.673 157	.339 258	.035 283	.006 52	.497 090	.030 16	24.4°
.673 212	.339 307	.035 426	.006 57	.497 067	.030 27	24.5°
.673 266	.339 357	.035 569	.006 63	.497 043	.030 39	24.6°
.673 321	.339 407	.035 712	.006 68	.497 019	.030 50	24.7°
.673 376	.339 457	.035 855	.006 73	.496 995	.030 62	24.8°
.673 431	.339 508	.035 998	.006 79	.496 970	.030 74	24.9°
.673 486	.339 559	.036 140	.006 84	.496 946	.030 85	25.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504
25.1°	8° 21′ 13″	.991 602	.981 082	.144 062
25.2°	8° 23′ 12″	.991 536	.980 932	.144 620
25.3°	8° 25′ 12″	.991 468	.980 782	.145 179
25.4°	8° 27′ 11″	.991 401	.980 631	.145 737
25.5°	8° 29′ 11″	.991 333	.980 479	.146 294
25.6°	8° 31′ 10″	.991 266	.980 327	.146 852
25.7°	8° 33′ 10″	.991 197	.980 175	.147 409
25.8°	8° 35′ 09″	.991 129	.980 022	.147 966
25.9°	8° 37′ 08″	.991 060	.979 868	.148 523
26.0°	8° 39′ 08″	.990 991	.979 714	.149 080
26.1°	8° 41′ 07″	.990 922	.979 559	.149 637
26.2°	8° 43′ 07″	.990 853	.979 403	.150 193
26.3°	8° 45′ 06″	.990 783	.979 247	.150 750
26.4°	8° 47′ 05″	.990 713	.979 091	.151 306
26.5°	8° 49′ 05″	.990 642	.978 933	.151 861
26.6°	8° 51′ 04″	.990 572	.978 776	.152 417
26.7°	8° 53′ 03″	.990 501	.978 617	.152 973
26.8°	8° 55′ 03″	.990 430	.978 458	.153 528
26.9°	8° 57′ 02″	.990 359	.978 299	.154 083
27.0°	8° 59′ 02″	.990 287	.978 139	.154 638
27.1°	9° 01′ 01″	.990 215	.977 978	.155 193
27.2°	9° 03′ 00″	.990 143	.977 817	.155 747
27.3°	9° 05′ 00″	.990 071	.977 655	.156 301
27.4°	9° 06′ 59″	.989 998	.977 493	.156 855
27.5°	9° 08′ 58″	.989 925	.977 330	.157 409
27.6°	9° 10′ 58″	.989 852	.977 167	.157 963
27.7°	9° 12′ 57″	.989 779	.977 003	.158 516
27.8°	9° 14′ 56″	.989 705	.976 838	.159 070
27.9°	9° 16′ 55″	.989 631	.976 673	.159 623
28.0°	9° 18′ 55″	.989 557	.976 507	.160 176
28.1°	9° 20′ 54″	.989 482	.976 341	.160 728
28.2°	9° 22′ 53″	.989 408	.976 174	.161 281
28.3°	9° 24′ 53″	.989 333	.976 007	.161 833
28.4°	9° 26′ 52″	.989 257	.975 839	.162 385
28.5°	9° 28′ 51″	.989 182	.975 670	.162 937
28.6°	9° 30′ 51″	.989 106	.975 501	.163 489
28.7°	9° 32′ 50″	.989 030	.975 331	.164 040
28.8°	9° 34′ 49″	.988 954	.975 161	.164 591
28.9°	9° 36′ 48″	.988 877	.974 990	.165 142
29.0°	9° 38′ 48″	.988 800	.974 819	.165 693
29.1°	9° 40′ 47″	.988 723	.974 647	.166 244
29.2°	9° 42′ 46″	.988 646	.974 475	.166 794
29.3°	9° 44′ 45″	.988 568	.974 302	.167 344
29.4°	9° 46′ 45″	.988 491	.974 128	.167 894
29.5°	9° 48′ 44″	.988 412	.973 954	.168 444
29.6°	9° 50′ 43″	.988 334	.973 779	.168 993
29.7°	9° 52′ 42″	.988 255	.973 604	.169 543
29.8°	9° 54′ 41″	.988 177	.973 428	.170 092
29.9°	9° 56′ 41″	.988 097	.973 251	.170 641
30.0°	9° 58′ 40″	988 018	.973 074	.171 189

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

U/L	V/L	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.673 486	.339 559	.036 140	.006 84	.496 946	.030 85	25.0°
.673 542	.339 610	.036 283	.006 89	.496 922	.030 97	25.1°
.673 598	.339 661	.036 426	.006 95	.496 897	.031 08	25.2°
.673 654	.339 712	.036 569	.007 00	.496 873	.031 20	25.3°
.673 710	.339 764	.036 711	.007 06	.496 848	.031 31	25.4°
.673 767	.339 815	.036 854	.007 11	.496 823	.031 43	25.5°
.673 824	.339 867	.036 997	.007 17	.496 798	.031 54	25.6°
.673 881	.339 920	.037 139	.007 22	.496 773	.031 66	25.7°
.673 938	.339 972	.037 282	.007 28	.496 748	.031 77	25.8°
.673 996	.340 025	.037 425	.007 33	.496 723	.031 89	25.9°
.674 054	.340 078	.037 567	.007 39	.496 698	.032 00	26.0°
.674 112	.340 131	.037 710	.007 44	.496 673	.032 12	26.1°
.674 170	.340 184	.037 852	.007 50	.496 647	.032 23	26.2°
.674 229	.340 238	.037 995	.007 56	.496 622	.032 34	26.3°
.674 287	.340 292	.038 138	.007 61	.496 596	.032 46	26.4°
.674 346	.340 346	.038 280	.007 67	.496 570	.032 57	26.5°
.674 406	.340 400	.038 422	.007 73	.496 544	.032 69	26.6°
.674 465	.340 454	.038 565	.007 78	.496 518	.032 80	26.7°
.674 525	.340 509	.038 707	.007 84	.496 492	.032 91	26.8°
.674 585	.340 564	.038 850	.007 90	.496 466	.033 03	26.9°
.674 645	.340 619	.038 992	.007 96	.496 440	.033 14	27.0°
.674 706	.340 674	.039 135	.008 01	.496 414	.033 25	27.1°
.674 766	.340 730	.039 277	.008 07	.496 387	.033 37	27.2°
.674 827	.340 786	.039 419	.008 13	.496 361	.033 48	27.3°
.674 888	.340 842	.039 561	.008 19	.496 334	.033 59	27.4°
.674 950	.340 898	.039 704	.008 25	.496 308	.033 71	27.5°
.675 012	.340 955	.039 846	.008 31	.496 281	.033 82	27.6°
.675 074	.341 011	.039 988	.008 37	.496 254	.033 93	27.7°
.675 136	.341 068	.040 130	.008 43	.496 227	.034 05	27.8°
.675 198	.341 125	.040 273	.008 49	.496 200	.034 16	27.9°
.675 261	.341 183	.040 415	.008 54	.496 173	.034 27	28.0°
.675 324	.341 240	.040 557	.008 60	.496 145	.034 38	28.1°
.675 387	.341 298	.040 699	.008 66	.496 118	.034 50	28.2°
.675 450	.341 356	.040 841	.008 73	.496 091	.034 61	28.3°
.675 514	.341 415	.040 983	.008 79	.496 063	.034 72	28.4°
.675 578	.341 473	.041 125	.008 85	.496 036	.034 83	28.5°
.675 642	.341 532	.041 267	.008 91	.496 008	.034 94	28.6°
.675 706	.341 591	.041 409	.008 97	.495 980	.035 06	28.7°
.675 771	.341 650	.041 551	.009 03	.495 952	.035 17	28.8°
.675 836	.341 710	.041 693	.009 09	.495 924	.035 28	28.9°
.675 901	.341 769	.041 835	.009 15	.495 896	.035 39	29.0°
.675 966	.341 829	.041 977	.009 21	.495 868	.035 50	29.1°
.676 032	.341 889	.042 119	.009 28	.495 839	.035 61	29.2°
.676 098	.341 950	.042 261	.009 34	.495 811	.035 72	29.3°
.676 164	.342 010	.042 402	.009 40	.495 782	.035 84	29.4°
.676 230	.342 071	.042 544	.009 46	.495 754	.035 95	29.5°
.676 297	.342 132	.042 686	.009 53	.495 725	.036 06	29.6°
.676 364	.342 193	.042 828	.009 59	.495 696	.036 17	29.7°
.676 431	.342 255	.042 970	.009 65	.495 668	.036 28	29.8°
.676 498	.342 316	.043 111	.009 72	.495 639	.036 39	29.9°
.676 566	.342 378	.043 253	.009 78	.495 610	.036 50	30.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189
30.1°	10° 00′ 39″	.987 938	.972 897	.171 738
30.2°	10° 02′ 38″	.987 858	.972 719	.172 286
30.3°	10° 04′ 37″	.987 778	.972 540	.172 834
30.4°	10° 06′ 37″	.987 698	.972 361	.173 382
30.5°	10° 08′ 36″	.987 617	.972 181	.173 929
30.6°	10° 10′ 35″	.987 536	.972 000	.174 477
30.7°	10° 12′ 34″	.987 455	.971 820	.175 024
30.8°	10° 14′ 33″	.987 373	.971 638	.175 571
30.9°	10° 16′ 32″	.987 291	.971 456	.176 117
31.0°	10° 18′ 32″	.987 209	.971 273	.176 664
31.1°	10° 20′ 31″	.987 127	.971 090	.177 210
31.2°	10° 22′ 30″	.987 044	.970 907	.177 756
31.3°	10° 24′ 29″	.986 962	.970 722	.178 302
31.4°	10° 26′ 28″	.986 879	.970 537	.178 847
31.5°	10° 28′ 27″	.986 795	.970 352	.179 392
31.6°	10° 30′ 26″	.986 712	.970 166	.179 938
31.7°	10° 32′ 25″	.986 628	.969 980	.180 482
31.8°	10° 34′ 24″	.986 544	.969 792	.181 027
31.9°	10° 36′ 24″	.986 459	.969 605	.181 571
32.0°	10° 38′ 23″	.986 375	.969 417	.182 116
32.1°	10° 40′ 22″	.986 290	.969 228	.182 659
32.2°	10° 42′ 21″	.986 205	.969 039	.183 203
32.3°	10° 44′ 20″	.986 119	.968 849	.183 747
32.4°	10° 46′ 19″	.986 033	.968 658	.184 290
32.5°	10° 48′ 18″	.985 948	.968 467	.184 833
32.6°	10° 50′ 17″	.985 861	.968 276	.185 376
32.7°	10° 52′ 16″	.985 775	.968 084	.185 918
32.8°	10° 54′ 15″	.985 688	.967 891	.186 460
32.9°	10° 56′ 14″	.985 601	.967 698	.187 002
33.0°	10° 58′ 13″	.985 514	.967 504	.187 544
33.1°	11° 00′ 12″	.985 426	.967 310	.188 086
33.2°	11° 02′ 11″	.985 339	.967 115	.188 627
33.3°	11° 04′ 10″	.985 251	.966 920	.189 168
33.4°	11° 06′ 09″	.985 162	.966 724	.189 709
33.5°	11° 08′ 08″	.985 074	.966 528	.190 250
33.6°	11° 10′ 07″	.984 985	.966 331	.190 790
33.7°	11° 12′ 06″	.984 896	.966 133	.191 330
33.8°	11° 14′ 05″	.984 807	.965 935	.191 870
33.9°	11° 16′ 04″	.984 717	.965 736	.192 410
34.0°	11° 18′ 03″	.984 627	.965 537	.192 949
34.1°	11° 20′ 02″	.984 537	.965 337	.193 488
34.2°	11° 22′ 01″	.984 447	.965 137	.194 027
34.3°	11° 24′ 00″	.984 356	.964 936	.194 566
34.4°	11° 25′ 59″	.984 265	.964 735	.195 104
34.5°	11° 27′ 58″	.984 174	.964 533	.195 643
34.6°	11° 29′ 57″	.984 083	.964 330	.196 180
34.7°	11° 31′ 56″	.983 991	.964 127	.196 718
34.8°	11° 33′ 55″	.983 899	.963 923	.197 256
34.9°	11° 35′ 54″	.983 807	.963 719	.197 793
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.676 566	.342 378	.043 253	.009 78	.495 610	.036 50	30.0°
.676 634	.342 441	.043 395	.009 84	.495 580	.036 61	30.1°
.676 702	.342 503	.043 536	.009 91	.495 551	.036 72	30.2°
.676 770	.342 566	.043 678	.009 97	.495 522	.036 83	30.3°
.676 839	.342 629	.043 819	.010 04	.495 492	.036 94	30.4°
.676 908	.342 692	.043 961	.010 10	.495 463	.037 05	30.5°
.676 977	.342 755	.044 102	.010 17	.495 433	.037 16	30.6°
.677 046	.342 819	.044 244	.010 23	.495 403	.037 27	30.7°
.677 116	.342 882	.044 385	.010 30	.495 374	.037 38	30.8°
.677 186	.342 947	.044 527	.010 36	.495 344	.037 49	30.9°
.677 256	.343 011	.044 668	.010 43	.495 314	.037 60	31.0°
.677 326	.343 075	.044 810	.010 49	.495 284	.037 71	31.1°
.677 397	.343 140	.044 951	.010 56	.495 253	.037 82	31.2°
.677 468	.343 205	.045 092	.010 62	.495 223	.037 92	31.3°
677 539	.343 270	.045 234	.010 69	.495 193	.038 03	31.4°
.677 610	.343 336	.045 375	.010 76	.495 162	.038 14	31.5°
.677 682	.343 401	.045 516	.010 82	.495 132	.038 25	31.6°
.677 754	.343 467	.045 658	.010 89	.495 101	.038 36	31.7°
.677 826	.343 534	.045 799	.010 96	.495 070	.038 47	31.8°
.677 898	.343 600	.045 940	.011 03	.495 039	.038 58	31.9°
.677 971	.343 667	.046 081	.011 09	.495 008	.038 68	32.0°
.678 044	.343 733	.046 222	.011 16	.494 977	.038 79	32.1°
.678 117	.343 801	046 363	.011 23	.494 946	.038 90	32.2°
.678 190	.343 868	046 504	.011 30	.494 915	.039 01	32.3°
.678 264	.343 936	.046 646	.011 36	.494 884	.039 12	32.4°
.678 338	.344 003	.046 787	.011 43	.494 852	.039 22	32.5°
.678 412	.344 071	.046 928	.011 50	.494 821	.039 33	32.6°
678 487	.344 140	.047 069	.011 57	.494 789	.039 44	32.7°
678 561	.344 208	.047 210	.011 64	.494 757	.039 54	32.8°
.678 636	.344 277	.047 350	.011 71	.494 725	.039 65	32.9°
.678 712	.344 346	.047 491	.011 78	.494 694	.039 76	33.0°
678 787	.344 415	.047 632	.011 85	.494 662	.039 87	33.1°
678 863	.344 485	.047 773	.011 92	.494 629	.039 97	33.2°
678 939	.344 555	.047 914	.011 99	.494 597	.040 08	33.3°
.679 015	.344 625	.048 055	.012 06	.494 565	.040 19	33.4°
679 092	.344 695	.048 195	.012 13	.494 533	.040 29	33.5°
.679 168	.344 765	.048 336	.012 20	.494 500	.040 40	33.6°
.679 245	.344 836	048 477	.012 27	.494 468	.040 50	33.7°
.679 323	.344 907	.048 618	.012 34	.494 435	.040 61	33.8°
.679 400	.344 978	.048 758	.012 41	.494 402	.040 72	33.9°
.679 478	.345 049	.048 899	.012 48	.494 369	.040 82	34.0°
.679 556	.345 121	.049 039	.012 55	.494 336	.040 93	34.1°
.679 634	.345 193	.049 180	.012 62	.494 303	.041 03	34.2°
.679 713	.345 265	.049 321	.012 69	.494 270	.041 14	34.3°
.679 792	.345 338	.049 461	.012 77	.494 237	.041 24	34.4°
.679 871	.345 410	.049 602	.012 84	.494 204	.041 35	34.5°
.679 950	.345 483	.049 742	.012 91	.494 170	.041 45	34.6°
.680 030	.345 556	.049 882	.012 98	.494 137	.041 56	34.7°
.680 110	.345 630	.050 023	.013 06	.494 103	.041 66	34.8°
.680 190	.345 703	.050 163	.013 13	.494 070	.041 77	34.9°
.680 270	.345 777	.050 304	.013 20	.494 036	.041 87	35.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330
35.1°	11° 39′ 52″	.983 622	.963 309	.198 866
35.2°	11° 41′ 50″	.983 529	.963 103	.199 403
35.3°	11° 43′ 49″	.983 436	.962 897	.199 939
35.4°	11° 45′ 48″	.983 343	.962 690	.200 475
35.5°	11° 47′ 47″	.983 249	.962 483	.201 010
35.6°	11° 49′ 46″	.983 155	.962 275	.201 546
35.7°	11° 51′ 45″	.983 061	.962 066	.202 081
35.8°	11° 53′ 44″	.982 966	.961 857	.202 616
35.9°	11° 55′ 43″	.982 872	.961 648	.203 151
36.0°	11° 57′ 41″	.982 777	.961 438	.203 685
36.1°	11° 59′ 40″	.982 681	.961 227	.204 219
36.2°	12° 01′ 39″	.982 586	.961 016	.204 753
36.3°	12° 03′ 38″	.982 490	.960 804	.205 286
36.4°	12° 05′ 37″	.982 394	.960 592	.205 820
36.5°	12° 07′ 36″	.982 298	.960 379	.206 353
36.6°	12° 09′ 34″	.982 201	.960 165	.206 886
36.7°	12° 11′ 33″	.982 104	.959 951	.207 418
36.8°	12° 13′ 32″	.982 007	.959 737	.207 951
36.9°	12° 15′ 31″	.981 910	.959 522	.208 483
37.0°	12° 17′ 30″	.981 812	.959 306	.209 014
37.1°	12° 19′ 28″	.981 715	.959 090	.209 546
37.2°	12° 21′ 27″	.981 617	.958 874	.210 077
37.3°	12° 23′ 26″	.981 518	.958 657	.210 608
37.4°	12° 25′ 25″	.981 420	.958 439	.211 139
37.5°	12° 27′ 23″	.981 321	.958 221	.211 669
37.6°	12° 29′ 22″	.981 222	.958 002	.212 199
37.7°	12° 31′ 21″	.981 122	.957 783	.212 729
37.8°	12° 33′ 20″	.981 023	.957 563	.213 259
37.9°	12° 35′ 18″	.980 923	.957 342	.213 788
38.0°	12° 37′ 17″	.980 823	.957 121	.214 317
38.1°	12° 39′ 16″	.980 722	.956 900	.214 846
38.2°	12° 41′ 14″	.980 622	.956 678	.215 375
38.3°	12° 43′ 13″	.980 521	.956 455	.215 903
38.4°	12° 45′ 12″	.980 420	.956 232	.216 431
38.5°	12° 47′ 11″	.980 318	.956 009	.216 959
38.6°	12° 49′ 09″	.980 217	.955 785	.217 486
38.7°	12° 51′ 08″	.980 115	.955 560	.218 013
38.8°	12° 53′ 07″	.980 012	.955 335	.218 540
38.9°	12° 55′ 05″	.979 910	.955 109	.219 067
39.0°	12° 57′ 04″	.979 807	.954 883	.219 593
39.1°	12° 59′ 02″	.979 704	.954 656	.220 119
39.2°	13° 01′ 01″	.979 601	.954 429	.220 645
39.3°	13° 03′ 00″	.979 498	.954 201	.221 171
39.4°	13° 04′ 58″	.979 394	.953 973	.221 696
39.5°	13° 06′ 57″	.979 290	.953 744	.222 221
39.6°	13° 08′ 56″	.979 186	.953 514	.222 745
39.7°	13° 10′ 54″	.979 081	.953 284	.223 270
39.8°	13° 12′ 53″	.978 977	.953 054	.223 794
39.9°	13° 14′ 51″	.978 872	.952 823	.224 318
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	$o = mL - nD$		$Z = mL - nD$		Δ
		m	n	m	n	
.680 270	.345 777	.050 304	.013 20	.494 036	.041 87	35.0°
.680 351	.345 851	.050 444	.013 28	.494 002	.041 98	35.1°
.680 432	.345 926	.050 584	.013 35	.493 968	.042 08	35.2°
.680 513	.346 000	.050 724	.013 42	.493 934	.042 18	35.3°
.680 595	.346 075	.050 865	.013 50	.493 900	.042 29	35.4°
.680 677	.346 150	.051 005	.013 57	.493 866	.042 39	35.5°
.680 759	.346 226	.051 145	.013 64	.493 831	.042 49	35.6°
.680 841	.346 301	.051 285	.013 72	.493 797	.042 60	35.7°
.680 923	.346 377	.051 425	.013 79	.493 762	.042 70	35.8°
.681 006	.346 453	.051 565	.013 87	.493 728	.042 81	35.9°
.681 089	.346 529	.051 705	.013 94	.493 693	.042 91	36.0°
.681 173	.346 606	.051 845	.014 02	.493 658	.043 01	36.1°
.681 256	.346 683	.051 985	.014 09	.493 623	.043 11	36.2°
.681 340	.346 760	.052 125	.014 17	.493 588	.043 22	36.3°
.681 424	.346 837	.052 265	.014 24	.493 553	.043 32	36.4°
.681 509	.346 915	.052 405	.014 32	.493 518	.043 42	36.5°
.681 594	.346 993	.052 545	.014 39	.493 483	.043 52	36.6°
.681 679	.347 071	.052 685	.014 47	.493 447	.043 63	36.7°
.681 764	.347 149	.052 825	.014 55	.493 412	.043 73	36.8°
.681 849	.347 228	.052 965	.014 62	.493 376	.043 83	36.9°
.681 935	.347 307	.053 104	.014 70	.493 341	.043 93	37.0°
.682 021	.347 386	.053 244	.014 78	.493 305	.044 03	37.1°
.682 107	.347 465	.053 384	.014 85	.493 269	.044 14	37.2°
.682 194	.347 545	.053 523	.014 93	.493 233	.044 24	37.3°
.682 281	.347 625	.053 663	.015 01	.493 197	.044 34	37.4°
.682 368	.347 705	.053 803	.015 09	.493 161	.044 44	37.5°
.682 455	.347 785	.053 942	.015 16	.493 125	.044 54	37.6°
.682 543	.347 866	.054 082	.015 24	.493 089	.044 64	37.7°
.682 631	.347 947	.054 221	.015 32	.493 052	.044 74	37.8°
.682 719	.348 028	.054 361	.015 40	.493 016	.044 84	37.9°
.682 808	.348 109	.054 500	.015 48	.492 979	.044 94	38.0°
.682 896	.348 191	.054 640	.015 55	.492 943	.045 04	38.1°
.682 986	.348 273	.054 779	.015 63	.492 906	.045 14	38.2°
.683 075	.348 355	.054 919	.015 71	.492 869	.045 24	38.3°
.683 164	.384 437	.055 058	.015 79	.492 832	.045 34	38.4°
.683 254	.348 520	.055 197	.015 87	.492 795	.045 44	38.5°
.683 344	.348 603	.055 336	.015 95	.492 758	.045 54	38.6°
.683 435	.348 686	.055 476	.016 03	.492 721	.045 64	38.7°
.683 526	.348 769	.055 615	.016 11	.492 683	.045 74	38.8°
.683 617	.348 853	.055 754	.016 19	.492 646	.045 84	38.9°
.683 708	.348 937	.055 893	.016 27	.492 608	.045 94	39.0°
.683 799	.349 021	.056 032	.016 35	.492 571	.046 04	39.1°
.683 891	.349 106	.056 171	.016 43	.492 533	.046 14	39.2°
.683 983	.349 190	.056 310	.016 51	.492 495	.046 24	39.3°
.684 076	.349 275	.056 450	.016 59	.492 458	.046 34	39.4°
.684 168	.349 361	.056 589	.016 67	.492 420	.046 43	39.5°
.684 261	.349 446	.056 727	.016 75	.492 382	.046 53	39.6°
.684 354	.349 532	.056 866	.016 83	.492 343	.046 63	39.7°
.684 448	.349 618	.057 005	.016 92	.492 305	.046 73	39.8°
.684 542	.349 704	.057 144	.017 00	.492 267	.046 83	39.9°
.684 636	.349 791	.057 283	.017 08	.492 229	.046 92	40.0°

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841
40.1°	13° 18′ 48″	.978 661	.952 359	.225 365
40.2°	13° 20′ 47″	.978 555	.952 127	.225 888
40.3°	13° 22′ 46″	.978 449	.951 893	.226 410
40.4°	13° 24′ 44″	.978 343	.951 660	.226 933
40.5°	13° 26′ 43″	.978 236	.951 426	.227 455
40.6°	13° 28′ 41″	.978 130	.951 191	.227 977
40.7°	13° 30′ 40″	.978 023	.950 956	.228 498
40.8°	13° 32′ 38″	.977 915	.950 720	.229 019
40.9°	13° 34′ 37″	.977 808	.950 484	.229 540
41.0°	13° 36′ 35″	.977 700	.950 247	.230 061
41.1°	13° 38′ 34″	.977 592	.950 010	.230 581
41.2°	13° 40′ 32″	.977 484	.949 772	.231 102
41.3°	13° 42′ 31″	.977 375	.949 533	.231 621
41.4°	13° 44′ 29″	.977 266	.949 294	.232 141
41.5°	13° 46′ 28″	.977 157	.949 055	.232 660
41.6°	13° 48′ 26″	.977 048	.948 815	.233 179
41.7°	13° 50′ 25″	.976 938	.948 575	.233 698
41.8°	13° 52′ 23″	.976 828	.948 334	.234 216
41.9°	13° 54′ 22″	.976 718	.948 092	.234 734
42.0°	13° 56′ 20″	.976 608	.947 850	.235 252
42.1°	13° 58′ 18″	.976 497	.947 608	.235 769
42.2°	14° 00′ 17″	.976 387	.947 365	.236 286
42.3°	14° 02′ 15″	.976 276	.947 121	.236 803
42.4°	14° 04′ 14″	.976 164	.946 877	.237 320
42.5°	14° 06′ 12″	.976 053	.946 632	.237 836
42.6°	14° 08′ 10″	.975 941	.946 387	.238 352
42.7°	14° 10′ 09″	.975 829	.946 142	.238 868
42.8°	14° 12′ 07″	.975 716	.945 895	.239 383
42.9°	14° 14′ 06″	.975 604	.945 649	.239 898
43.0°	14° 16′ 04″	.975 491	.945 401	.240 413
43.1°	14° 18′ 02″	.975 378	.945 154	.240 927
43.2°	14° 20′ 01″	.975 264	.944 906	.241 442
43.3°	14° 21′ 59″	.975 151	.944 657	.241 956
43.4°	14° 23′ 57″	.975 037	.944 408	.242 469
43.5°	14° 25′ 56″	.974 923	.944 158	.242 982
43.6°	14° 27′ 54″	.974 808	.943 908	.243 495
43.7°	14° 29′ 52″	.974 694	.943 657	.244 008
43.8°	14° 31′ 50″	.974 579	.943 405	.244 520
43.9°	14° 33′ 49″	.974 464	.943 154	.245 032
44.0°	14° 35′ 47″	.974 348	.942 901	.245 544
44.1°	14° 37′ 45″	.974 233	.942 648	.246 055
44.2°	14° 39′ 44″	.974 117	.942 395	.246 566
44.3°	14° 41′ 42″	.974 001	.942 141	.247 077
44.4°	14° 43′ 40″	.973 884	.941 887	.247 588
44.5°	14° 45′ 38″	.973 768	.941 632	.248 098
44.6°	14° 47′ 37″	.973 651	.941 377	.248 608
44.7°	14° 49′ 35″	.973 534	.941 121	.249 117
44.8°	14° 51′ 33″	.973 416	.940 864	.249 627
44.9°	14° 53′ 31″	.973 299	.940 607	.250 135
45.0°	14° 55′ 29″	.973 181	.940 350	.250 644

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

$\frac{U}{L}$	$\frac{V}{L}$	o = mL — nD		Z = mL — nD		Δ
		m	n	m	n	
.684 636	.349 791	.057 283	.017 08	.492 229	.046 92	40.0°
.684 730	.349 878	.057 422	.017 16	.492 190	.047 02	40.1°
.684 825	.349 965	.057 561	.017 24	.492 151	.047 12	40.2°
.684 920	.350 052	.057 699	.017 33	.492 113	.047 22	40.3°
.685 015	.350 140	.057 838	.017 41	.492 074	.047 31	40.4°
.685 110	.350 228	.057 977	.017 49	.492 035	.047 41	40.5°
.685 206	.350 316	.058 115	.017 57	.491 996	.047 51	40.6°
.685 302	.350 404	.058 254	.017 66	.491 957	.047 60	40.7°
.685 398	.350 493	.058 393	.017 74	.491 918	.047 70	40.8°
.685 495	.350 582	.058 531	.017 82	.491 879	.047 80	40.9°
.685 592	.350 671	.058 670	.017 91	.491 839	.047 89	41.0°
.685 689	.350 761	.058 808	.017 99	.491 800	.047 99	41.1°
.685 786	.350 851	.058 946	.018 07	.491 760	.048 08	41.2°
.685 884	.350 941	.059 085	.018 16	.491 721	.048 18	41.3°
.685 982	.351 031	.059 223	.018 24	.491 681	.048 28	41.4°
.686 081	.351 121	.059 362	.018 33	.491 641	.048 37	41.5°
.686 179	.351 212	.059 500	.018 41	.491 602	.048 47	41.6°
.686 278	.351 303	.059 638	.018 50	.491 562	.048 56	41.7°
.686 377	.351 395	.059 776	.018 58	.491 521	.048 66	41.8°
.686 477	.351 486	.059 915	.018 67	.491 481	.048 75	41.9°
.686 576	.351 578	.060 053	.018 75	.491 441	.048 85	42.0°
.686 677	.351 671	.060 191	.018 84	.491 401	.048 94	42.1°
.686 777	.351 763	.060 329	.018 92	.491 360	.049 04	42.2°
.686 878	.351 856	.060 467	.019 01	.491 320	.049 13	42.3°
.686 978	.351 949	.060 605	.019 09	.491 279	.049 22	42.4°
.687 080	.352 042	.060 743	.019 18	.491 239	.049 32	42.5°
.687 181	.352 136	.060 881	.019 26	.491 198	.049 41	42.6°
.687 283	.352 229	.061 019	.019 35	.491 157	.049 51	42.7°
.687 385	.352 324	.061 157	.019 44	.491 116	.049 60	42.8°
.687 487	.352 418	.061 295	.019 52	.491 075	.049 69	42.9°
.687 590	.352 513	.061 433	.019 61	.491 034	.049 79	43.0°
.687 693	.352 608	.061 571	.019 70	.490 992	.049 88	43.1°
.687 796	.352 703	.061 708	.019 79	.490 951	.049 97	43.2°
.687 900	.352 798	.061 846	.019 87	.490 910	.050 06	43.3°
.688 004	.352 894	.061 984	.019 96	.490 868	.050 16	43.4°
.688 108	.352 990	.062 122	.020 05	.490 827	.050 25	43.5°
.688 212	.353 086	.062 259	.020 14	.490 785	.050 34	43.6°
.688 317	.353 183	.062 397	.020 22	.490 743	.050 43	43.7°
.688 422	.353 280	.062 534	.020 31	.490 701	.050 53	43.8°
.688 527	.353 377	.062 672	.020 40	.490 659	.050 62	43.9°
.688 633	.353 474	.062 809	.020 49	.490 617	.050 71	44.0°
.688 739	.353 572	.062 947	.020 58	.490 575	.050 80	44.1°
.688 845	.353 670	.063 084	.020 67	.490 533	.050 89	44.2°
.688 952	.353 768	.063 222	.020 75	.490 491	.050 98	44.3°
.689 059	.353 867	.063 359	.020 84	.490 448	.051 08	44.4°
.689 166	.353 966	.063 496	.020 93	.490 406	.051 17	44.5°
.689 273	.354 065	.063 634	.021 02	.490 363	.051 26	44.6°
.689 381	.354 164	.063 771	.021 11	.490 320	.051 35	44.7°
.689 489	.354 264	.063 908	.021 20	.490 278	.051 44	44.8°
.689 597	.354 364	.064 045	.021 29	.490 235	.051 53	44.9°
.689 706	.354 464	.064 182	.021 38	.490 192	.051 62	45.0°

[4] MAINTENANCE OF SURFACE.

(a) Elevation of Curves:

The approximate formula

$$E = .00066\ DS^2$$

in which

E = Elevation in inches of the outer rail at the gage line,
D = Degree of Curve,
and S = Velocity in miles per hour,

will give essentially correct theoretical elevation for the outer rail of curves and is recommended for ordinary practice.

This formula will give results which are expressed in the following table:

ELEVATION OF OUTER RAIL IN INCHES.

Degree of Curve.	Velocity in Miles per Hour.													Degree of Curve.
	10	15	20	25	30	35	40	45	50	55	60	65	70	
1	0	⅛	¼	⅜	⅝	¾	1⅛	1⅜	1⅝	2	2⅜	2¾	3¼	1
2	⅛	⅜	½	⅞	1⅛	1⅝	2⅛	2⅝	3¼	4	4¾	5½	6½	2
3	¼	½	¾	1¼	1¾	2⅜	3⅛	4	4⅞	6	7⅛	8⅜	9¾	3
4	¼	⅝	1	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	9½	......	......	4
5	⅜	¾	1¼	2	3	4	5¼	6⅝	8¼	......	......	......	......	5
6	⅜	1	1⅝	2½	3½	4⅞	6¼	8	......	......	......	......	......	9
7	½	1⅛	1⅞	2⅞	4⅛	5⅝	7⅜	......	......	......	......	......	......	7
8	½	1¼	2⅛	3¼	4¾	6½	8⅜	......	......	......	......	......	......	8
9	⅝	1⅜	2⅜	3¾	5⅜	7¼	......	......	......	......	......	......	......	9
10	¾	1½	2⅝	4⅛	5⅞	8⅛	......	......	......	......	......	......	......	10
11	¾	1¾	2⅞	4½	6½	8⅞	......	......	......	......	......	......	......	11
12	⅞	1⅞	3⅛	4⅞	7⅛	......	......	......	......	......	......	......	......	12
13	⅞	2	3⅜	5⅜	7¾	......	......	......	......	......	......	......	......	13
14	1	2⅛	3⅝	5¾	8⅜	......	......	......	......	......	......	......	......	1
15	1	2¼	3⅞	6¼	8⅞	......	......	......	......	......	......	......	......	15
16	1⅛	2½	4¼	6⅝	......	......	......	......	......	......	......	......	......	16
17	1¼	2⅝	4½	7	......	......	......	......	......	......	......	......	......	17
18	1¼	2¾	4¾	7½	......	......	......	......	......	......	......	......	......	18
19	1⅜	2⅞	5	7¾	......	......	......	......	......	......	......	......	......	19
20	1⅜	3	5¼	8⅛	......	......	......	......	......	......	......	......	......	20

Since the elevation required is a function of the train speed this speed is the first element to be determined.

In general, in determining speed, consideration should be given to the traffic and the elevation fixed to give the greatest degree of economy in train operation.

Where easement curves are used the elevation should be attained and run out as prescribed under "Maintenance of Line, (b) Curves; Use of Easement Curves."

---

[4] Adopted, Vol. 3, 1902, pp. 56-59, 78-87; Vol. 5, 1904, pp. 528-533, 535, 562, 563; Vol. 6, 1905, pp. 754-757, 759-761; Vol. 11, Part 2, 1910, pp. 935, 944; Vol. 12, Part 1, 1911, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145.

Where easement curves are not used the full elevation should be maintained throughout a simple curve and throughout the sharper curve of a compound curve, if possible, the elevation being attained or run out on the tangent and lighter curve respectively at a rate approximately one inch in a distance in feet equal to 1¾ times the speed in miles per hour.

Ordinarily an elevation of 8 inches should not be exceeded. Speed of trains should be regulated to conform to the maximum elevation used.

The inner rail should be maintained at grade.

(b) Vertical Curves:

The use of vertical curves to connect changes in gradient is recommended.

The length should be determined by the gradients to be connected. On Class A roads rates of change of 0.1 per station on summits and 0.05 per station in sags should not be exceeded. On minor roads 0.2 per station on summits and 0.1 per station in sags may be used.

(c) Proper Methods of Tamping:

(1) *Earth or Clay Ballast:*

Tools: Shovel equipped with iron cuff or handle; broad-faced tamping bars.

Method: Tamp each tie from 18 inches inside of the rail to end of tie with handle of shovel or tamping bar. If possible, tamp the end of the tie outside of rail first and let train pass over before tamping inside of rail; give special attention to tamping under the rail; tamp center of ties loosely with the blade of the shovel; the dirt or clay between the ties should be placed in layers and firmly packed with feet or otherwise, so that it will quickly shed the water; the earth should not be banked above the bottom of the ends of the ties; the filling between the ties should not touch the rail and should be as high as, or higher than, the top of the ties in the middle of the track.

(2) *Cinder Ballast (Railroad Product):*

Tools: Shovel, tamping bar or tamping pick.

Method: Same as for gravel.

(3) *Burnt Clay Ballast:*

Tools: Shovel only in soft material. When burnt very hard, tamping pick or bar should be used.

Method: Tamp 15 inches inside of rail to end of tie, tamping end of tie first, letting train pass before tamping inside of rail; tamp center loosely; tamp well between the ties; dress ballast same as for earth or cinders.

(4) *Broken Stone or Furnace Slag:*

Tools: Shovel, tamping pick, tamping machine, stone forks.

Method: Tamp 15 inches inside of rail to end of tie; if possible, tamp end of tie outside of rail first and allow train to pass over before tamping inside of rail; tamp well under the rail; tamp well under ties from end of same; do not tamp center of tie; finish in accordance with standard section.

(5) *Chats, Gravel or Chert Ballast:*

Tools: Shovel, tamping pick or tamping bar. For light traffic, shovel tamping is sufficient. For heavy traffic, the tamping pick or tamping bar should be used. The tamping bar is recommended instead of the tamping pick for ordinary practice.

Method: Tamp solid from a point 15 inches inside of rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow train to pass over before tamping inside of rail; care should be taken not to disturb the old bed. Tie should be tamped solidly from the end, using pick or tamping bar. After train has passed, the center of the tie should be loosely tamped with the blade of the shovel; dress same as stone ballast.

(6) *General:*

When not surfacing out of face, as in case of picking up low joints or other low places, the general level of the track should not be disturbed. Where the rails are out of level, but where the difference in elevation is not excessive and is uniform over long stretches of track, a difference in elevation between the two rails of ⅜ inch may be permitted to continue until such time as the track would ordinarily be surfaced out of face.

[5] MAINTENANCE OF GAGE.

(a) Appliances and methods used to prevent spreading of track and canting of rails on curves:

(1) Tie plates are recommended in all cases where economy in maintenance will result from their use.

---

[5] Adopted, Vol 5, 1904, pp. 534, 535, 563-569; Vol. 6, 1905, pp. 749, 750, 757, 759-761; Vol. 7, 1906, pp. 654, 664; Vol. 10, Part 1, 1909, pp. 398, 400, 467; Vol. 11, Part 2, 1910, pp. 934, 935, 944-946; Vol. 12, Part 1, 1911, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145.

(2) Shoulder tie plates are recommended in preference to rail braces except for guard rails and stock rails at switches where braces should be used.

(3) For heavy traffic, shoulder tie plates should be used on all ties on curves.

(4) For medium traffic, shoulder tie plates should be used on all ties on curves over three degrees.

(5) For light traffic, where tie plates are not used, the outside of both rails on curves should be double spiked when necessary.

(b) General:

(1) The gage (tool) used should be the standard gage recommended.

(2) Within proper limits, a slight variation of gage from the standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than one-half inch, providing such increase is uniform.

(3) Wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to ½ inch; it should be corrected by closing in or by interchanging the low and high rails.

(4) Where track is to be spiked to standard gage, the rail should be held against the gage with a bar while the spike is being driven.

(5) Spikes should be started vertically and square, and so driven that the face of the spike shall come in contact with the base of rail; the spike should never have to be straightened while being driven.

(6) The outside spikes of both rails should be near one edge of the tie, and the inside spikes near the other. The inside and outside spikes should be spaced as far apart as the face and character of the tie will permit. The ordinary practice should be to drive the spike 2½ inches from the outer edge of the tie. The old spike holes should be plugged.

[6] WIDTH OF STANDARD FLANGEWAY.

The clear width of standard flangeway for all frogs and between main rails and guard rails should be 1¾ inches, measured at the gage line, for all tracks of 4 feet 8½ inches gage.

---

[6] Adopted, Vol. 10, 1909, pp. 398, 466, 467.

[7] GAGE ON CURVES.

Curves eight degrees and under should be standard gage. Gage should be widened one-eighth inch for each two degrees or fraction thereof over eight degrees, to a maximum of 4 feet 9¼ inches for tracks of standard gage. Gage, including widening due to wear, should never exceed 4 feet 9½ inches.

Where frogs occur on the inside of curves the gage at the frog should be standard or the flangeway of the frog should be widened to compensate for the increased gage.

[8] SPEEDS OF TRAINS THROUGH CURVES AND TURNOUTS.

Diagrams of speeds of trains through curves and level turnouts are shown in following pages.

Relative Speeds Through Level Turnouts.

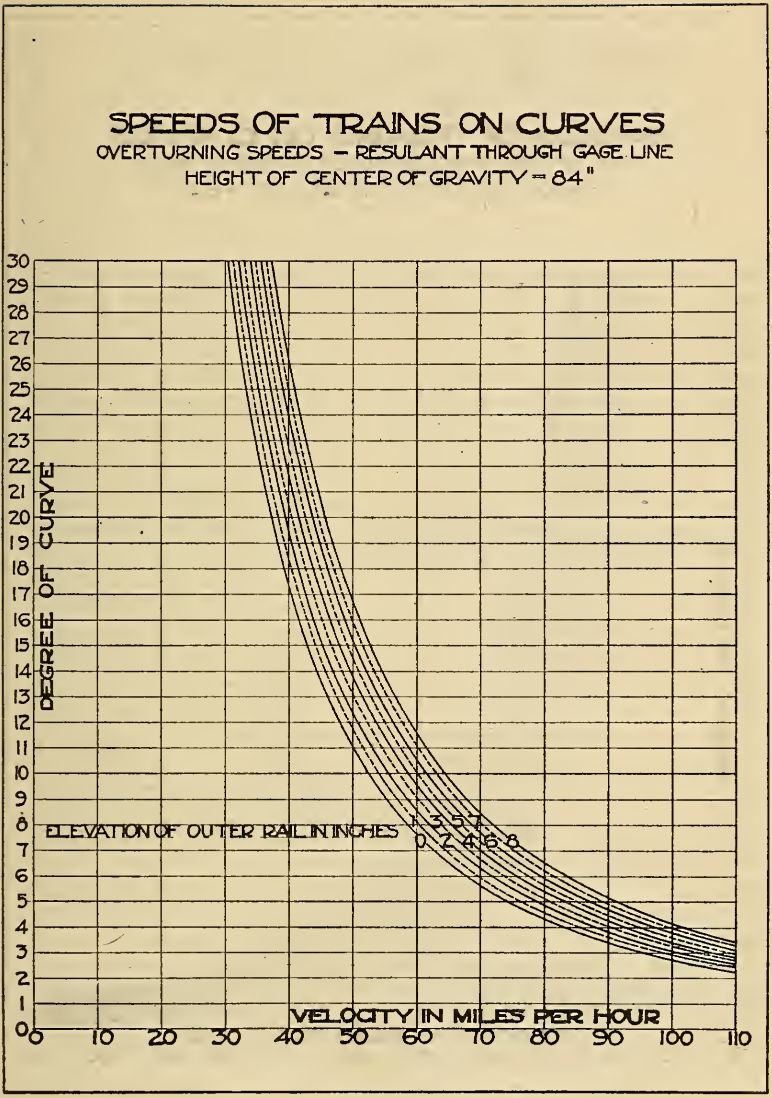
The following table shows relative speeds through level turnouts, to give the equivalent riding conditions to track elevated three inches less than theoretically required:

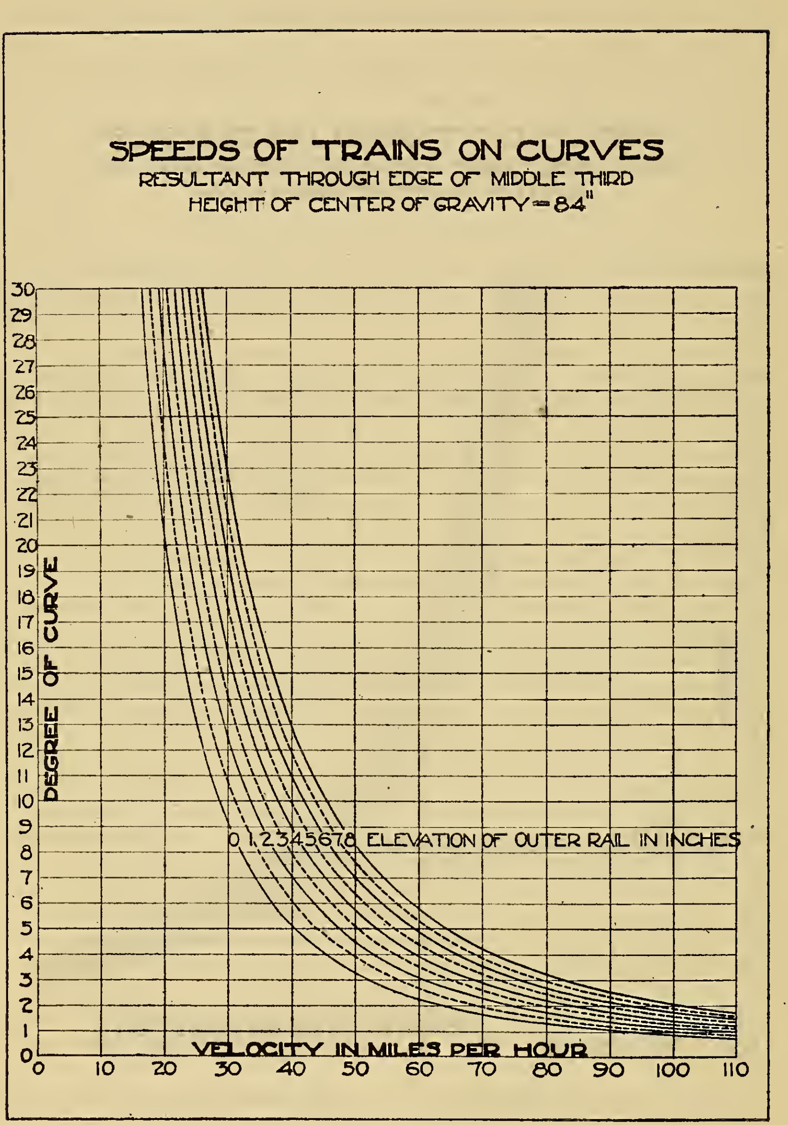
TURNOUT		SPEED Miles per Hour
Frog Number	Length of Switch	
4	11	9
5	11	12
6	11	13
7	16.5	17
8-10	16.5	20
11-14	22	27
15	33	37
16-24	33	40

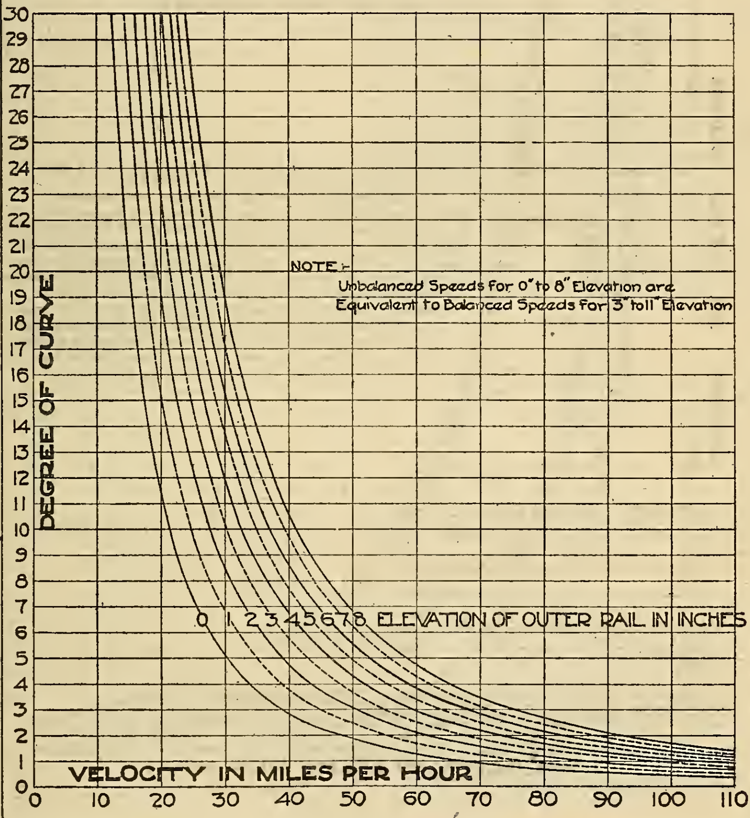
---

[7] Adopted, Vol. 11, Part 2, 1910, pp. 942, 954, 955; Vol. 16, 1915, pp. 733, 1145.

[8] Adopted, Vol. 15, 1914, pp. 594, 1063.


SPEEDS OF TRAINS ON CURVES
OVERTURNING SPEEDS – RESULANT THROUGH GAGE LINE
HEIGHT OF CENTER OF GRAVITY = 84"
DEGREE OF CURVE
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
ELEVATION OF OUTER RAIL IN INCHES
1 3 5 7
0 2 4 6 8
VELOCITY IN MILES PER HOUR
0
10
20
30
40
50
60
70
80
90
100
110

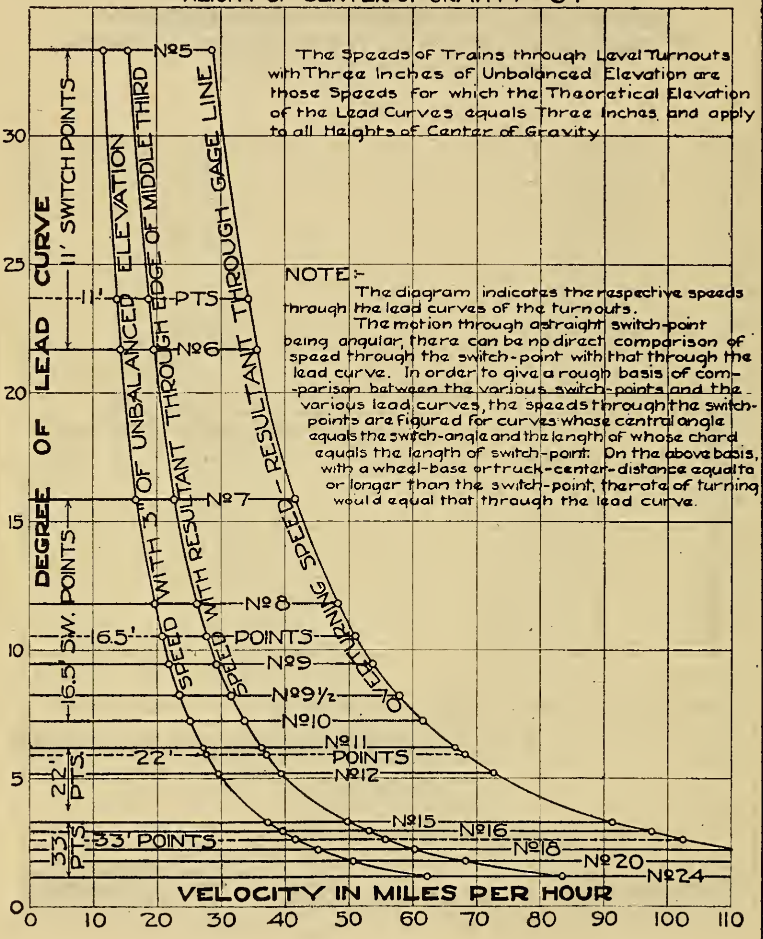

SPEEDS OF TRAINS ON CURVES
RESULTANT THROUGH EDGE OF MIDDLE THIRD
HEIGHT OF CENTER OF GRAVITY = 84"
DEGREE OF CURVE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
0 1 2 3 4 5 6 7 8 ELEVATION OF OUTER RAIL IN INCHES
VELOCITY IN MILES PER HOUR
0 10 20 30 40 50 60 70 80 90 100 110



SPEEDS OF TRAINS ON CURVES
UNBALANCED ELEVATION = 3"
ALL HEIGHTS OF CENTER OF GRAVITY
THOSE SPEEDS OF TRAINS ON CURVES HAVING AN ELEVATION
OF THREE INCHES LESS THAN THE THEORETICAL ELEVATION

SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS

HEIGHT OF CENTER OF GRAVITY = 84"

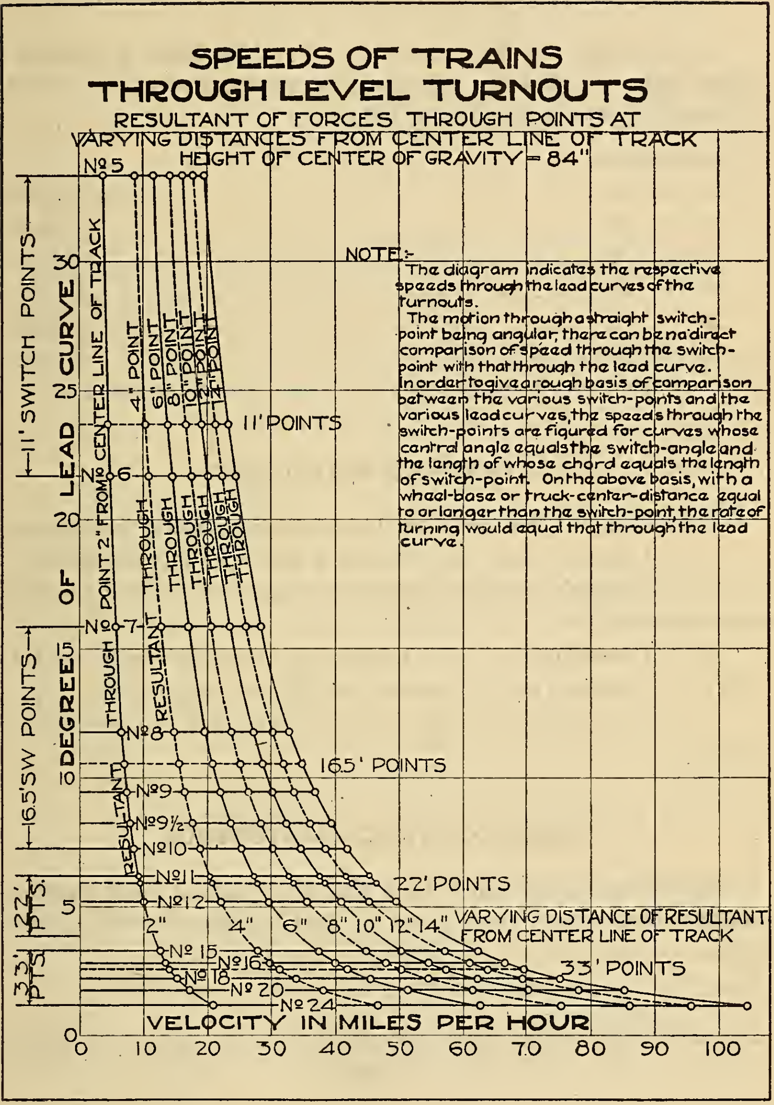


The Speeds of Trains through Level Turnouts with Three Inches of Unbalanced Elevation are those Speeds for which the Theoretical Elevation of the Lead Curves equals Three Inches and apply to all Heights of Center of Gravity.

NOTE:—

The diagram indicates the respective speeds through the lead curves of the turnouts.

The motion through a straight switch-point being angular, there can be no direct comparison of speed through the switch-point with that through the lead curve. In order to give a rough basis of comparison between the various switch-points and the various lead curves, the speeds through the switch-points are figured for curves whose central angle equals the switch-angle and the length of whose chord equals the length of switch-point. On the above basis, with a wheel-base or truck-center-distance equal to or longer than the switch-point, the rate of turning would equal that through the lead curve.



SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS

RESULTANT OF FORCES THROUGH POINTS AT VARYING DISTANCES FROM CENTER LINE OF TRACK

HEIGHT OF CENTER OF GRAVITY = 84"

NOTE:-

The diagram indicates the respective speeds through the lead curves of the turnouts.

The motion through a straight switch-point being angular, there can be no direct comparison of speed through the switch-point with that through the lead curve. In order to give a rough basis of comparison between the various switch-points and the various lead curves, the speeds through the switch-points are figured for curves whose central angle equals the switch-angle and the length of whose chord equals the length of switch-point. On the above basis, with a wheel-base or truck-center-distance equal to or longer than the switch-point, the rate of turning would equal that through the lead curve.

[9] TEMPERATURE EXPANSION FOR LAYING RAILS.

When laying rails their temperature should be taken by applying a thermometer. To allow for expansion the openings between the ends of adjacent 33-foot rails should be as follows:

TEMPERATURE. (Fahrenheit.)	ALLOWANCE.
—20° to 0°	$\frac{5}{16}$ inch
0° to 25°	$\frac{1}{4}$ inch
25° to 50°	$\frac{3}{16}$ inch
50° to 75°	$\frac{1}{8}$ inch
75° to 100°	$\frac{1}{16}$ inch

Over 100 degrees rails should be laid close without bumping.

[10] STANDARD RAIL JOINT.

A standard rail joint should fulfill the following general requirements:

(1) It should connect the rails into a uniform continuous girder.

(2) It should be strong enough to resist deformation or taking permanent set.

(3) It should prevent relative deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

(4) It should be as simple and of as few parts as possible to be effective.

[11] DESIGN OF TRACK FASTENINGS.

Where there is material leakage from track circuits, track fastenings should be so designed as to prevent contact between the metal and the ballast.

[12] SPECIFICATIONS FOR RELAYER RAIL FOR VARIOUS USES.

Definition.

1. Worn rails suitable for use in track are known as relayer rails.

---

[9] Adopted, Vol. 2, 1901, 109, 212.
[10] Adopted, Vol. 7, 1906, pp. 655, 657; Vol. 16, 1915, pp. 729, 1145.
[11] Adopted, Vol. 11, Part 2, 1910, pp. 935, 942, 944.
[12] Adopted, Vol. 21, 1920, pp. 192, 1374.

Classification.

2. Relayer rails shall be classified according to the wear on the side and top of the head:

(a) Side wear shall be represented by figures, 0 representing no side wear, 1, 2, 3, etc., representing the number of sixteenths of an inch wear on the side of the head at the gage ⅝-in. below the original top of the rail.

(b) Top wear shall be represented by capital letters, O representing no top wear, A representing 1/32-in., B, 2/32-in., C, 3/32 in., etc., wear, measured at the center of the rail.

(c) If the rail head is worn on both sides the first figure shall represent the side showing the greater wear, the letter the top wear, and the figure following the lesser side wear.

(d) The maximum wear allowed in each case shall be specified by the user or the purchaser.

Process and Section.

3. The process, as Bessemer, Open-Hearth, special alloy or process steel, the section, the original weight per yard and the splice drilling shall be specified.

Main Track Relayer Rails.

4. *Grade* 1.—Used rails suitable for main track on main or branch lines. They must be free from all physical defects and shall pass the A. R. E. A. Specifications for Steel Rail in all respects except wear. The surface of the rails of this grade must be fairly smooth and shall not have flat spots or wheel burns. They shall be sawed at the ends, not cut with a chisel. Drilling shall be uniform. Chemical analysis or the specifications under which the rails were originally purchased shall be furnished when requested by the purchaser. There shall be full length pieces, 30 or 33 feet long, and not over 10 per cent. of shorts varying in lengths by 1 ft. with a minimum length of 22 ft.

Resawing Rails.

5. *Grade* 2.—All rails with battered or otherwise defective ends, which if resawed would meet the Grade 1 requirements, shall be graded as Resawed Main Track Relayer Rails. In this case 90 per cent. of the rails shall be of uniform length, 27 ft. or over.

Side Track Relayer Rails.

6. *Grade* 3.—All used rails suitable for side tracks shall be included in this grade. They shall be not less than 15 ft. long. Rails too badly out of line or surface to be included in Grade 1 but straight enough to be easily spiked to line and gage shall be accepted. Drilling shall be uniform. Base shall be full or uniform width.

Any physical defects, such as broken lower flange, corroded, curved ends, burnt, ends battered, ends down, flat spots, head flow, line bent, piped, pitted, short, split end, split head, surface bent, twisted, worn under head, shall be specified where they occur and the extent of the defect shall be represented by the use of the term "slight," "moderate" or "bad."

Scrap Rails (Rolling Mill Rails).

7. *Grade* 4.—Rails of standard section not suitable for use as relayer rails. They shall be not less than 6 ft. long and shall be free from pipes, split heads and similar defects. Badly twisted rails or bent rails, frogs, switches and guard rails will not be accepted.

Scrap Rails.

8. *Grade* 5.—All used rails of any length or condition not meeting the above specifications shall be designated as Grade 5.

Marking and Shipping.

9. Rails when classified shall be marked with white paint on the web about 3 ft. from the end. The figure and letter representing the side and top wear shall be painted first, followed by a dash (—) and the grade number, except scrap rails, shall be marked by the grade number only. No two grades of rails shall be loaded in the same car.

Examples.

10. (a) Main track relayer rails having $\frac{3}{16}$-in. side wear and $\frac{3}{32}$-in. top wear would be classified and marked 3 C—1.

(b) Resawed main track relayer rails having ¼-in. side wear and $\frac{3}{32}$-in. top wear would be classified and marked 4 C—2.

(c) Side track relayer rails having ½-in. side wear and ⅛-in. top wear would be classified and marked 8 D—. If there are any physical defects, as curved ends, line bent, pitted, etc., they should be so classified and the extent of the defects specified as "slight," "moderate" or "bad."

(d) Side track relayer rails having ½-in. side wear on one side and ⅜-in. side wear on the other side, ⅛-in. top wear, would be classified and marked 8 D 6—3. If there are any physical defects, as curved ends, line bent, pitted, etc., they should be so classified and the extent of the defect specified as "slight," "moderate" or "bad."

[13] SPECIFICATIONS FOR STEEL CUT TRACK SPIKES.

(I) Material

Process.

1. The steel may be made by the Bessemer or Open-Hearth process.

(II) Physical Requirements

Tension Tests.

2. The full-size finished spikes, or the full-size bars from which the spikes are made, shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55,000
Yield point, lb. per sq. in.	0.5 tensile strength
Elongation in 2 in., per cent	25.

Bend Tests.

3. (a) The body of the full-size finished spikes shall bend cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(b) The head of the full-size finished spikes shall bend backward to the line of the face of the spike, without cracking on the outside of the bent portion.

Number of Tests.

4. (a) One tension and one bend test of each kind shall be made from each lot of 10 tons or fraction thereof.

(b) If any test specimen develops flaws, it may be discarded and another specimen substituted.

Retests.

5. If any tension test specimen breaks more than ¾-in. from the center of the gage length, a retest shall be allowed.

(III) Design

Workmanship.

6. The spikes shall conform to the dimensions specified by the purchaser. A variation of 1/64-inch under the specified dimension of the body of the spike, measured from the face to the back, and a variation of 1/32-inch over the specified dimensions of the body of the spike, measured across the face, will be permitted. A variation of 3/32-inch over and 1/32-inch under the specified dimensions of the head of the spike will be permitted. A variation of ⅛-inch from the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted.

(IV) Manufacture

Finish.

7. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

---

[13] Adopted, Vol. 21, 1920, pp. 175, 1367.

(V) Inspection

Inspection.

8. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

(VI) Shipment

Packing.

10. When spikes are shipped they shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of spike and name of manufacturer.

[15] SPECIFICATIONS FOR STEEL SCREW TRACK SPIKES

(I) Material

Process.

1. The steel may be made by the Bessemer or Open-Hearth process.

Finishing.

2. The heads of the spikes shall be formed and the threads rolled at a temperature not less than 750 deg. C.

(II) Physical Requirements

Tension Tests.

3. The full-sized finished spikes shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	60,000
Yield point, lb. per sq. in.	0.5 tensile strength
Elongation in 2 in., per cent	20.

Bend Tests.

4. The full-size finished spikes shall bend cold through 90 deg. around a pin the diameter of which is equal to three times the diameter of the spike, without cracking on the outside of the bent portion.

Number of Tests.

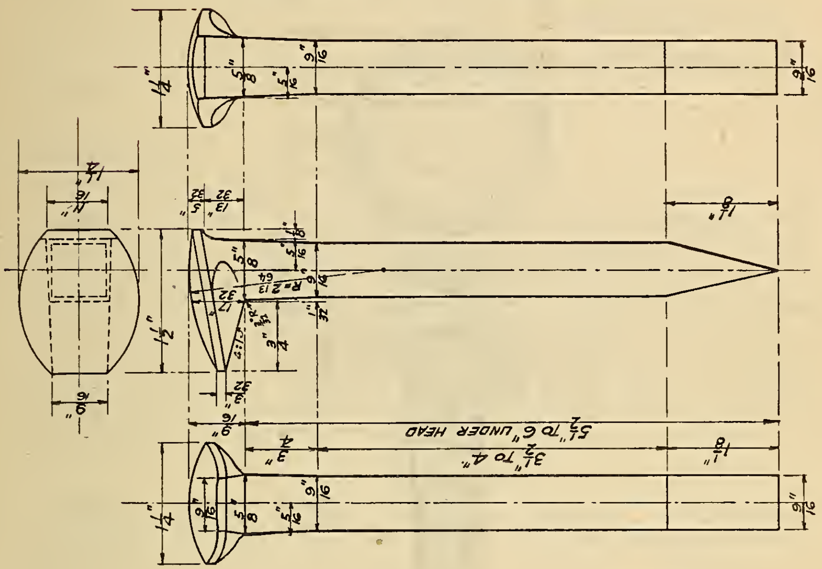
5. (a) One tension and one bend test shall be made from each lot of 100 kegs or fraction thereof.

(b) If any spike tested develops flaws, it may be discarded and another spike substituted.

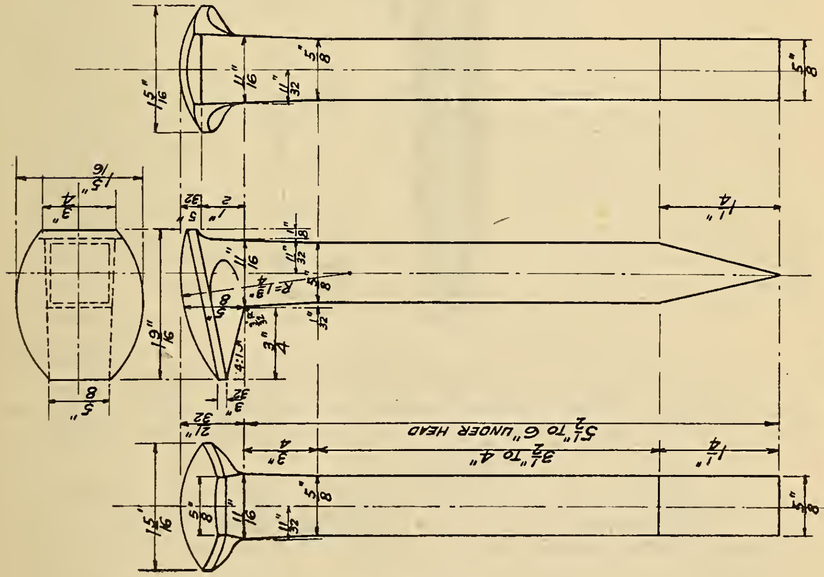
---

[16] Adopted, Vol. 21, 1920, pp. 181, 1369.

[14] DESIGN OF CUT TRACK SPIKE



DESIGN OF 9/16" CUT TRACK SPIKE.

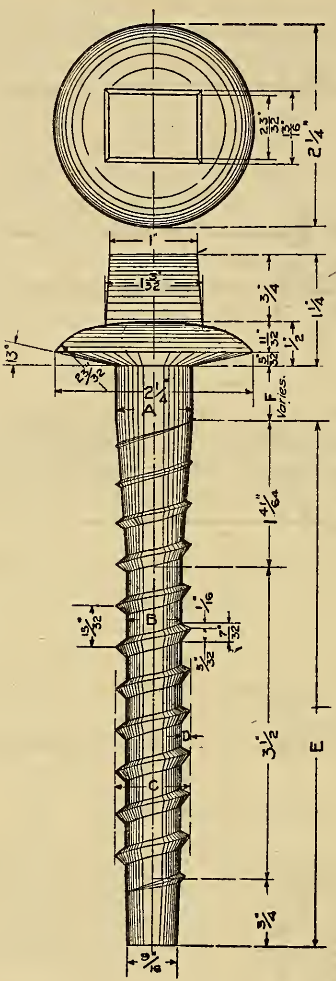


DESIGN OF 5/8" CUT TRACK SPIKE.

---

[14] Adopted, Vol. 22, 1921, pp. 653, 972.

[16] DESIGN OF SCREW SPIKE.



	LETTER	MAX.	STAND.	MIN.
Under Head	A	29/32	7/8	7/8
Root	B	21/32	5/8	5/8
Over Thread	C	29/32	7/8	7/8
Thread	D	9/64	1/8	1/8
Length	E	6 1/64	5 57/64	5 49/64
Length Under Head	F	Varies according to thickness of Rail Base and Tie Plate		

---

[16] Adopted, Vol. 18, 1917, pp. 428, 1488.

Retests.

6. (a) If the percentage of elongation of any tension test spike is less than that specified in Section 3, a retest shall be allowed.

(b) If any tension test spike breaks more than ¾-in. from the center of the gage length, a retest shall be allowed.

(III) Design

Workmanship.

7. The spike shall conform to the dimensions specified by the purchaser. The head shall be concentric with, and firmly joined to the body of the spike. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. A variation of 1/32-in. over the specified diameter of the unthreaded portion of the body of the spike will be permitted. A variation of 1/32-in. over the specified diameter of the threaded portion of the spike will be permitted. A variation of 1/16-in. under and ⅛-in. over in the reach of the head of the spike will be permitted. A variation of ⅛-in. from the specified length of the spike will be permitted.

(IV) Manufacture

Finish.

8. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

Marking.

9. A letter or brand indicating the manufacturer shall be pressed on the head of the spike while it is being formed.

(V) Inspection

Inspection.

10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

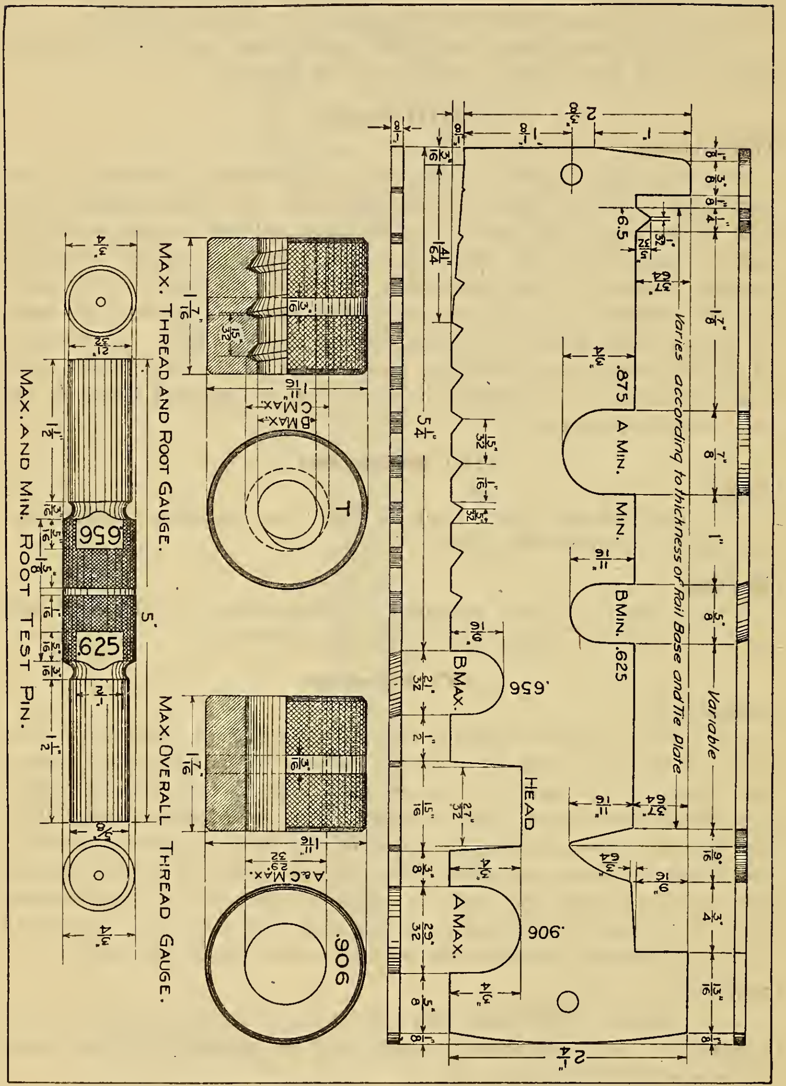
11. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

(VI) Shipment

Packing.

12. When spikes are shipped they shall be properly oiled to prevent rusting and shall be packed in good, serviceable packages. All packages shall be plainly marked as to material, size of spike and name of manufacturer, unless otherwise specified.

[17] TESTING GAGE FOR SCREW-SPIKE.


Max. Thread and Root Gauge.
Max. Overall Thread Gauge.
Max. and Min. Root Test Pin.
Varies according to thickness of Rail Base and Tie Plate
Variable
A Min.
Min.
B Min.
B Max.
A Max.
Head
.875
.625
.656
.906
T
C Max.
B Max.
A & C Max.
656
625
.906

---

[17] Adopted, Vol. 18, 1917, pp. 429, 1488.

[18] TIE-PLATES.

General Principles to be Followed in the Design.

Plates shall not be less than 6 inches in width, and as much wider as consistent with the class of ties to be used.

The length of the plates shall be not less than the safe bearing area of the ties divided by the width of the plate, and, when made for screw spikes, shall be so shaped as to provide proper support for the screw spikes.

The thickness of the plate shall be properly proportioned to the length.

Plates shall have a shoulder at least ½ of an inch high. The distance from the edge of rail base to the end of the tie-plate on the outer side must be uniform, and in excess of the projection inside of the rail base.

Where treated ties are used or where plates are for screw spikes, a flat bottom plate is preferable. Where ribs of any kind are used on base of plate, these shall be few in number and not to exceed ¼ inch in depth.

Punching must correspond to the slotting in the splice bars and, where advisable, may be so arranged that the plates may be used for joints. Spike holes may be punched for varying widths of rail base where the slotting will permit such punching without the holes interfering with each other and when the plate is of such design that the additional holes will not impair the strength of the plate.

[19] SPECIFICATIONS FOR STEEL TIE PLATES.

1. These Specifications cover two grades of steel tie plates, namely, Soft and Medium. The soft grade steel shall be used, unless otherwise specified.

Process.

(I) Material

2. Steel may be made by the Bessemer or Open-Hearth process.

Phosphorus.

(II) Chemical Requirements

3. (a) The steel shall conform to the following requirements as to chemical composition:

Carbon.

Phosphorus... { Bessemer—Not over 0.10 per cent.
Open-Hearth—Not over 0.05 per cent.

(b) Unless otherwise specified, the material will be furnished according to chemical composition only, in which case the minimum carbon shall be as follows:

Bessemer	*Soft Grade*	*Medium Grade*
Carbon	Not under 0.08 per cent.	Not under 0.12 per cent.
Open-Hearth	Soft Grade	Medium Grade
Carbon	Not under 0.15 per cent.	Not under 0.20 per cent.

---

[18] Adopted, Vol. 14, 1913, pp. 98, 1060.
[19] Adopted, Vol. 21, 1920, pp. 176, 1369.

Ladle Analysis.

4. (a) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements, carbon, manganese, phosphorus and sulphur, contained in the steel, one for each day and night turn, respectively. These analyses shall be made from drillings taken at least ⅛-inch beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(b) An analysis of each melt of Open-Hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least ⅛-inch beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analysis.

5. An analysis may be made by the purchaser from a finished tie plate representing each melt of Open-Hearth steel, and each melt or lot of 10 tons of Bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

(III) Physical Requirements

Bend Test.

6. The bend test specimens specified in Section 7 shall bend cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

Test Specimens.

7. Bend test specimens shall be taken from the finished tie plates, or from the rolled bars, and longitudinally with the rolling. They shall be rectangular in section, not less than ½-inch in width between the planed sides, and shall have two parallel faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

Optional Bend Test.

8. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 6:

A piece of the rolled bar shall bend cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section, where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

Number of Tests.

9. (a) One bend test shall be made from each melt of Open-Hearth steel, or from each melt or lot of 10 tons of Bessemer steel.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

Tension Tests.

10. (a) If desired by the purchaser or for the reason that the manufacturer does not make his own steel bars and is not able to make the chemical analysis of the steel, the material may be purchased to conform to the following minimum requirements as to tensile properties:

	Soft Grade	*Medium Grade*
Tensile strength, lb. per sq. in.	55,000	64,000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 2-in., per cent	$\frac{1,500,000}{\text{Tensile Str.}}$	$\frac{1,500,000}{\text{Tensile Str.}}$
But in no case less than	20 per cent.	18 per cent.
Elongation in 8-in., per cent	$\frac{1,400,000}{\text{Tensile Str.}}$	$\frac{1,400,000}{\text{Tensile Str.}}$
But in no case less than	18 per cent.	16 per cent.
Reduction of area, per cent	30 per cent.	25 per cent.

Test Specimens.

(b) The tension test specimens shall be taken from the finished tie plates, or from the rolled bar. They shall be cut so that the sides of the specimens are parallel to the direction in which the tie plates have been rolled.

(c) Tension test specimens may conform to the essential dimensions shown in Fig. 1 or Fig. 2. The 2-in. specimen (Fig. 1) shall have filleted shoulders, or threaded ones, to fit into the holders on the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen.

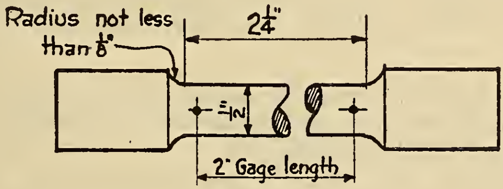


Fig. 1.

NOTE:—The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any form which will fit the Holders of the Testing Machine.

(d) Or, tension test specimens may be rectangular in section, in which case they shall be not less than ½-in. in width between the planed sides, and shall have two parallel faces as rolled. When the tie plates are of such a design that the rectangular specimens cannot be obtained without projecting ribs, these shall be planed off before the tests are made.

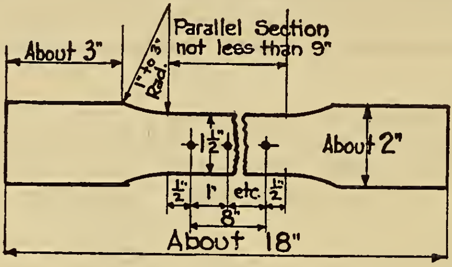


Fig. 2.

Number of Tests.

11. (a) One tension test shall be made from each melt of Open-Hearth steel, and from each melt or lot of 10 tons of Bessemer steel.

(b) If any test specimen shows defective machining, or develops flaws, or if it breaks outside the gage length, it may be discarded and another specimen substituted.

Retests.

12. If the percentage of elongation of any tension test specimen is less than that specified in Section 5, or if any part of the fracture is more than ¾-in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(IV) Design

Plan.

13. The tie plates shall conform to the drawings submitted to the manufacturer, with the following permissible variations:

Tolerance.

(a) For plates with shoulders parallel to the direction of rolling, a variation of 1/32-in. in thickness, ⅛-in. in rolled width, and 3/16-in. in sheared length will be permitted.

(b) For plates with shoulders perpendicular to the direction of rolling, a variation of 1/32-in. in thickness, ⅛-in. in rolled width, and ¼-in. in sheared length will be permitted. The distance from the face of shoulder to the ouside end of the plate shall not vary more than ¼-in., and from the face of shoulder to the inside end not more than ½-in.

(V) Manufacture

Workmanship.

14. The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail.

Finish.

15. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

Marking.

16. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

(VI) Inspection

Inspection.

17. The inspector representing the purchaser shall have free entry, at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

18. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

19. Samples tested in accordance with Section 5, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

(VII) Shipment

Packing.

20. Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb., unless otherwise specified.

[20] SPECIFICATIONS FOR WROUGHT-IRON TIE PLATES.

(I) Material

1. Plates shall be made of all-pig puddled iron.

(II) Physical Requirements

2. The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	48,000
Yield point, lb. per sq. in.	0.6 tensile strength
Elongation in 2-in., per cent	28
Elongation in 8-in., per cent	25
Reduction of area, per cent	37

Bend Tests.

3. The bend test specimen shall bend cold through 180 degrees without fracture around a pin the diameter of which is equal to the thickness of the specimen.

Test Specimens.

4. (a) The tension test specimens shall be taken from the finished tie plates, or from the rolled bar. They shall be cut so that the sides of the specimens are parallel to the direction in which the tie plates have been rolled.

(b) Tension test specimens may conform to the essential dimensions shown in Fig. 1 or Fig. 2. The 2-in. specimen (Fig. 1) shall have filleted shoulders, or threaded ends, to fit into the holders on the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen.

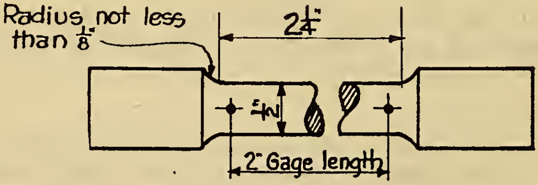


Fig. 1.

Note:—The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any form which will fit the Holders of the Testing Machine.

---

[20] Adopted, Vol. 21, 1920, pp. 182, 1369.

Number of Tests.

5. (a) One tension test and one bend test shall be made from each lot of 1,000 tie plates.

(b) If any test specimen from either of the bars originally selected to represent a lot of material contains surface defects not visible before testing, but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, the individual bar shall be rejected and one retest from a different bar will be allowed.

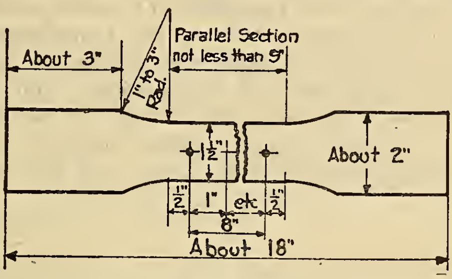


Fig. 2.

(III) Design

Plan.

6. The tie plates shall conform to the drawings submitted to the manufacturer, with the following permissible variations:

Variations.

(a) For plates with shoulders parallel to the direction of rolling, a variation of 1/32-in. in thickness, ⅛-in. in rolled width, and 3/16-in. in sheared length will be permitted.

(b) For plates with shoulders perpendicular to the direction of rolling, a variation of 1/32-in. in thickness, ⅛-in. in rolled width, and ¼-in. in sheared length will be permitted. The distance from the face of the shoulder to the outside end of plate shall not vary more than ¼-in., and from the face of shoulder to the inside end not more than ½-in.

(IV) Manufacture

Workmanship.

7. The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail and have a workmanlike finish.

Finish.

8. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from slivers, depressions, seams, crop ends and evidences of being burnt.

Marking.

9. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

(V) Inspection

Inspection.

10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

11. If either of the test bars selected to represent a lot does not conform to the requirements specified in Sections 2, 3, 4 and 5, the lot will be rejected.

(VI) Shipment

Packing.

12. Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb. for shipment, unless otherwise specified.

[21] SPECIFICATIONS FOR MALLEABLE IRON TIE PLATES.

(I) Material

1. Plates shall be made from furnace malleable iron.

(II) Physical Requirements

Tension Tests.

2. The tension test specimens specified in Section 4 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	45,000
Elongation in 2 in., per cent	7.5

Special Tests.

3. (a) All tie plates shall have cast thereon test lugs of a size proportional to the thickness of the tie plate, but not exceeding ⅝ by ¾-in. in cross-section. These lugs shall be attached to the tie plate at such a point that they will not interfere with the assembling of the tie plates, and may be broken off by the inspector.

(b) If the purchaser or his representative so desires, a tie plate may be tested to destruction. Such a tie plate shall show good, tough, malleable iron.

---

[21] Adopted, Vol. 21, 1920, pp. 185, 1369.

Tension Test Specimens.

4. (a) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Specimens whose mean diameter at the smallest section is less than 19/32-in. will not be accepted for test.

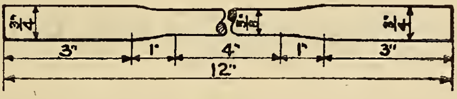


Fig. 1.

(b) A set of three tension test specimens shall be cast from each melt, without chills, using risers of sufficient height to secure sound bars.

The specimens shall be suitably marked for identification with the melt. Each set of specimens so cast shall be placed in some one oven containing tie plates to be annealed.

Number of Tests.

5. (a) After annealing, three tension test specimens shall be selected by the inspector as representing the tie plates in the oven from which these specimens are taken.

(b) If the first specimen conforms to the specified requirements, or if, in the event of failure of the first specimen, the second and third specimens conform to the requirements, the tie plates in that oven shall be accepted, except that any tie plate may be rejected if its test lug shows that it has not been properly annealed. If either the second or third specimen fails to conform to the requirements, the entire contents of that oven shall be rejected.

Re-annealing.

6. Any tie plates rejected for insufficient annealing may be re-annealed once. The re-annealed tie plates shall be inspected and if the remaining test lugs or tie plates broken as specimens show the tie plates to be thoroughly annealed, they shall be accepted; if not, they shall be finally rejected.

(III) Design

Plan.

7. Tie plates shall conform to the drawing submitted to the manufacturer, with the following permissible variations:

Variation.

(a) The length and width shall not vary more than ⅛-in. from the dimensions shown.

(b) The thickness shall not vary more than 1/32-in. from the dimensions shown.

(IV) Manufacture

Workmanship.

8. The plates shall be straight and out of wind on the surface which forms the bearing for the rail, and shall be made in a workmanlike manner.

Finish.

9. The finished tie plate shall be well cleaned and free from warping, shrinkage, cracks, blow-holes, fins, and other imperfections.

Marking.

10. The manufacturer's identification mark and the pattern numbers assigned by the purchaser shall be cast on all tie plates in such positions that they will not interfere with the service of the tie plate.

(V) Inspection

Inspection.

11. (a) The inspector representing the purchaser shall have free entry, all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(b) The manufacturer shall be required to keep a record of each melt from which tie plates are produced, showing tensile strength and elongation of test specimens cast from such melts. These records shall be available and shown to the inspector whenever required.

Rejection.

12. Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works may be rejected, and, if rejected, shall be replaced by the manufacturer free of cost to the purchaser.

(VI) Shipment

Packing.

13. Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb., for shipment, unless otherwise specified.

[22] ANTI-CREEPERS.

GENERAL REQUIREMENTS TO BE MET IN THE DESIGN AND MANUFACTURE.

Anti-creepers shall be so designed as to fit two or more different weights of rail and so that they can be readily removed and re-applied.

They must be easy to apply under full-ballasted track.

---

[22] Adopted, Vol. 14, 1913, pp. 107, 1066.

They must be substantial enough to stand driving to place without chance of breaking.

The least possible number of movable parts is desirable.

When applied they must be in position rigidly enough to carry the tie with them in any kind of ballast without slipping.

They shall be made with sufficient take-up to permit of proper tightening.

When in place they must not loosen sufficiently to render them inoperative when the rail slacks back.

Controlling or delicate parts should be made of non-rustable material.

Anti-creepers made of steel shall be of sufficient size to minimize their destruction by rust.

Anti-creepers made of malleable iron must be from furnace malleable iron properly annealed, and of sufficient weight to prevent breakage and distortion in application or in service.

[23] PLANS FOR TURNOUTS, FROGS, SWITCHES AND FIXTURES.

(SEE FOLDER FOR PLANS.)

Plan No.

101—16′ 6″ Split Switch, with uniform risers.
102—16′ 6″ Split Switch, with graduated risers.
103—11′ 0″ Split Switch, with uniform risers.
104—11′ 0″ Split Switch, with graduated risers.
105—22′ 0″ Split Switch, with uniform risers.
106—22′ 0″ Split Switch, with graduated risers.
107—30′ 0″ Split Switch, with uniform risers.
108—30′ 0″ Split Switch, with graduated risers.
190—Diagram Preferred Names of Parts for Split Switch, with uniform risers.
191—Diagram Preferred Names of Parts for Split Switch, with graduated risers.
201—Details Split Switch Fixtures (General).
202—Details Split Switch Fixtures (Special Features).
203—Details Split Switch Fixtures (heel plates and turnout plates).
204—Details Split Switch Fixtures (heel plates and turnout plates for 22′ and 30′ switches).
210—Illustration Bills of Material for 11′ 0″ and 16′ 6″ Split Switches.
211—Illustration Bills of Material for 22′ 0″ and 30′ 0″ Split Switches.
301—No. 6 Bolted Rigid Frog.
302—No. 7 Bolted Rigid Frog.
303—No. 8 Bolted Rigid Frog.
304—No. 10 Bolted Rigid Frog.
305—Detail of Plates for Nos. 6, 7, 8 and 10 Rigid Frogs.
306—No. 11 Bolted Rigid Frog.
307—No. 16 Bolted Rigid Frog.
308—Detail of Plates for Nos. 11, 16 and 20 Rigid Frogs.
320—Data for Laying Out Bolted Rigid Frogs.
331—No. 6 Clamp Frog.

---

[23] Adopted, Vol. 21, 1920, pp. 188, 1370, 1371; Vol. 22, 1921, pp. 676, 678, 973, 974.

Plan No.
332—No. 7 Clamp Frog.
333—No. 8 Clamp Frog.
334—No. 10 Clamp Frog.
335—Detail of Plates for Nos. 6, 7, 8 and 10 Clamp Frogs.
390—Diagram Preferred Names of Parts for Bolted Rigid Frogs.
391—Diagram Preferred Names of Parts for Clamp Frogs.
401—No. 10 Spring Rail Frog.
402—No. 8 Spring Rail Frog.
403—No. 11 Spring Rail Frog.
490—Diagram Preferred Names of Parts for Spring Rail Frogs.
501—Details of Guard Rails.
502—Details of Guard Rail Fixtures.
590—Diagram Preferred Names of Parts for Guard Rails.
601—No. 6 Railbound Manganese Steel Frogs.
602—No. 7 Railbound Manganese Steel Frogs.
603—No. 8 Railbound Manganese Steel Frogs.
604—No. 10 Railbound Manganese Steel Frogs.
605—No. 11 Railbound Manganese Steel Frogs.
606—No. 16 Railbound Manganese Steel Frogs.
607—No. 20 Railbound Manganese Steel Frogs.
651—No. 6 Frog, Solid Manganese Steel.
652—No. 7 Frog, Solid Manganese Steel.
653—No. 8 Frog, Solid Manganese Steel.
654—No. 10 Frog, Solid Manganese Steel.
655—No. 11 Frog, Solid Manganese Steel.
690—Diagram Preferred Names of Parts for Railbound Manganese Steel Frogs.
691—Diagram Preferred Names of Parts for Solid Manganese Steel Frogs.
901—Layout No. 6 Turnout and Crossover.
902—Layout No. 7 Turnout and Crossover.
903—Layout No. 8 Turnout and Crossover, with Rigid Frogs.
904—Layout No. 8 Turnout and Crossover, with Spring Frogs.
905—Layout No. 10 Turnout and Crossover.
906—Layout No. 11 Turnout and Crossover.
907—Layout No. 16 Turnout and Crossover.
908—Layout No. 20 Turnout and Crossover.

[24] SPECIFICATIONS FOR SWITCHES, FROGS, CROSSINGS AND GUARD RAILS.

GENERAL INSTRUCTION.

1. The purchaser will furnish the manufacturer specifications and drawings, giving rail sections, splice drilling, angles, alinement and general dimensions, and such special details as may be required.

2. Unless otherwise specified the construction, design and details shall conform to the plans adopted by the American Railway Engineering Association as recommended practice. For track structures for which no such plans have been adopted, the manufacturer shall, when requested, submit for approval detail drawings.

---

[24] Adopted, Vol. 22, 1921, pp. 654, 973.

3. The detailed drawings shall be on sheets 22 in. wide between outside border lines, with inside border lines ½ in. from the top and bottom. The standard length of the sheet shall be 30 in. between outside border lines with inside border lines ½ in. from the right-hand edge and 1½ in. from the left-hand edge. When longer sheets are necessary they shall be in multiples of 6 in. and folded back to the standard length.

Drawings shall be confined to one subject. The title shall be placed in the lower right-hand corner. The scale of the general drawings shall be 1½ in. equals one foot, where practicable. Details not less than 3 in. equals one foot wherever practicable. Dimensions and distances under 2 ft. should be shown in inches; 2 ft. and over in feet and inches. Cross-sections shall be section lined for the material to be indicated in accordance with standard sections as shown in the A.R.E.A. Manual. Manganese steel section to be indicated by heavy single lines.

4. The drawings shall be part of the specifications. Anything that is not shown on the drawings, but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished, the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications that is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, the manufacturer shall notify the purchaser and shall not proceed with the work until instructed to do so.

MATERIAL.

Rail.

5. The rail used shall be first quality open-hearth steel of the section called for, manufactured according to A.R.E.A. specifications or to Rail Manufacturers' standard specifications, unless otherwise specified.

Grey Iron Castings.

6. Grey iron castings shall be of a good commercial grade of medium grey iron.

Steel Castings.

7. Steel castings shall be of good commercial grade manufactured in accordance with standard specifications of the American Society for Testing Materials for steel castings class "B"; except that steel castings exposed to wheel wear shall have a hardness approximately that of rail steel.

Cast Manganese Steel.

8. The cast manganese steel shall conform to the standard specifications of the Manganese Track Society (page 410, Volume 18, A.R.E.A. Proceedings.)

Malleable Iron Castings.

9. Malleable iron castings shall be of a good commercial grade, properly annealed.

Rolled or Forged Steel.

10. Rolled or forged steel parts shall be of a medium grade of commercial mild steel. Parts exposed to wheel wear shall be equal in hardness to rail steel.

Fillers.

11. Fillers shall be of rolled or forged steel, wrought iron or of good quality grey cast iron as called for on plans and as specified.

Heel Risers.

12. Heel risers shall be as called for on plans and provide wearing surface equal in hardness to rail steel.

Foot Guards.

13. Metal foot guards as shown on plans shall be of rolled steel or malleable iron. Wooden foot guards shall be good quality hard wood. Filler blocks when acting as foot guards may be of grey iron.

Bolts.

14. Bolts, other than where heat treated bolts are called for on plans or specified, shall be of mild carbon steel and shall have a tensile strength of not less than 50,000 lb. per square inch and an elongation of not less than 15 per cent. in 8 in.

Heat treated or high tensile bolts shall be of carbon or alloy steel and conform to the following minimum requirements:

Tensile Strength	100,000 lb.
Yield Point	70,000 lb.
Elongation in 2 in.	15 per cent.
Reduction of Area	40 per cent.

Full-size bolts shall bend cold without cracking through 180 deg. around a pin of the same diameter as the bolt. The yield point, elongation, and reduction of area may be determined from a finished bolt or from a test piece ½ in. by 2 in. turned from a finished bolt. Nuts may be Bessemer or open-hearth carbon steel not heat treated and shall be of sufficient thickness to develop the full strength of the bolt.

Rivets.

15. Rivets shall be made of steel manufactured in accordance with the standard specifications of the American Society for Testing Materials for rivet steel for ship or structural work.

Reinforcing Bars.

16. Reinforcing bars shall be of wrought iron or mild open-hearth steel.

Plates.

17. Switch plates, special frog tie plates, and bearing plates shall be of mild open-hearth steel.

Switch Clips.

18. Switch clips shall be of mild open-hearth steel, except special designs which may be of cast steel or malleable iron.

Switch Rods.

19. Switch rods shall be of mild rolled steel or wrought iron.

Stops and Hold-Downs.

20. Stops and hold-downs shall be of mild rolled steel or wrought iron.

Anti-Creeping Device.

21. Anti-creeping devices shall be of mild rolled steel or wrought iron.

Braces.

22. Braces shall be of mild rolled steel, malleable iron or cast steel.

Washers.

23. Washers shall be of mild rolled steel, malleable iron or cast steel.

Nut Locks.

24. Nut locks shall be of good strong spring steel.

Switch Heel Blocks.

25. Switch heel blocks shall be of grey iron, cast or forged steel, as specified.

Springs.

26. The steel in springs shall conform to the standard specifications of the American Society for Testing Materials for carbon steel bars for railway springs. Springs when forced down solid and held in the compressed position for thirty seconds, upon release, must not vary from their original free length.

Spring Housings.

27. Spring housings shall be of grey cast iron, malleable iron or cast steel.

Forged Crossing Knees.

28. Forged crossing knees shall be of mild rolled open-hearth steel or wrought iron.

Special Splice Bars.

29. Special splice bars shall be of mild rolled steel or cast steel.

WORKMANSHIP.

Workmanship.

30. Workmanship shall be first-class and in accordance with best current practice. The assembly of the several parts shall be such that uniformity of detail and finish will result.

Alinement and Surface.

31. The alinement and surface of all finished work shall be even and true and conform to the angles specified.

Length.

32. Length of frogs and crossing arms shall not vary more than ¼ in. from lengths specified. Switch-point rails and guard rails shall not vary more than ½ in. from length specified. Rail ends shall be cut square to the axis of the rail, unless otherwise required.

Flangeways.

33. The width of flangeways shall not be less than nor more than 1/16 in. greater than the width specified, when measured on the level of gage line ⅝ in. below tread surface. Flangeways shall not be less than 1⅞ in. deep measured from top of the tread surface, unless otherwise specified.

Bending.

34. Bends shall be made accurately in arcs of circles and without injury to the material. It is desired that rails be bent cold. If heating of the rails is resorted to it must be done in a manner so as not to injure the metal.

Planing.

35. All planing must be true and all abutting surfaces must fit accurately.

Grinding.

36. Running surfaces of the manganese steel parts shall be ground to practically as good a surface as that of the rolled rail. Manganese steel portions fitting into rails or other parts shall be ground to a good fit.

Drilling and Punching.

37. All holes in carbon steel rails must be drilled. In other parts all holes for turned pins or bolts and for tight fit of rough bolts must be

drilled. Drilling to be done accurately, on bevel where necessary. Punching will be permitted only in wrought iron or mild steel parts for rivets, loose rough bolts and spikes, except when such holes come so close together or close to the edge of the piece that the metal between holes or between hole and edge is less in width than the thickness of the material, in which case holes must be drilled.

Fit of Bolts.

38. Main or body bolts in frogs and crossings shall have a tight fit in straight true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than $\frac{1}{16}$ in. in drilled or punched holes and not more than $\frac{1}{8}$ in. in cored holes. Threads must be U. S. Standard, accurately cut within tolerance of best practice for cut threads. Nuts must have a tight fit.

Rivets.

39. Rivets shall be of full diameter called for on plans and rivet holes shall not be more than $\frac{1}{16}$ in. greater in diameter. When not otherwise called for by plans or specifications, rivets shall have standard button or cone heads of uniform size for the same size rivet. The heads shall be concentric with the holes. Countersunk rivets shall be flush with the surface and fill the countersink.

Fit of Fillers, Braces and Reinforcing Bars.

40. Fillers, except as otherwise called for or permitted by plans and specifications, shall fit closely into the fishing space of the rail and into the fillets of the web for not less than $\frac{1}{2}$ in. below the head and above the base flange. When the raised brand of the rail interferes with fit of filler the brand shall be removed. Fillers shall be grooved or cut to clear rivet heads and bolt heads. Beveled or straight end filler where specified shall not vary more than $\frac{1}{2}$-inch from being flush with end of rail.

Switch braces shall fit the fishing space of the rail when the brace is tight against the shoulder of the switch plate.

Reinforcing bars shall fill the height of the fishing space of the rail.

Plates and Bars.

41. All plates must be flat and true to surface. Bars must be straight and of the full size called for.

Painting.

42. No paint, tar or other covering shall be used unless specified, and, in any case, shall not be applied before final inspection.

Welding.

43. No welding shall be permitted on rails or on surfaces of other parts exposed to wheel wear. Welding in other portions may be permitted if in the judgment of the inspector the strength of the piece is not impaired.

Marking.

44. The finished articles shall be plainly stamped with ¾ in. figures and letters for identification. The manufacturer's name or initials, section and weight of rail and month and year of manufacture must be stamped on a rail portion of the structure not exposed to wheel wear and where marking can be plainly seen, or may be stamped on a separate rust-proof plate, riveted to the web of the rail, in which case smaller letters may be used. Frogs must be marked with the frog number. All loose parts or fixtures shall be similarly stamped with suitable size letters and figures, the stamping also to show the numbers of the parts appearing on the plan and detail number, where established. On cast parts all or part of the lettering may be cast on the piece. All heat-treated bolts shall be marked on the head with letter or symbol indicating the manufacturer.

INSPECTION.

45. Material and workmanship shall be at all times subject to inspection by a duly authorized representative of the purchaser. The inspector shall have all reasonable facilities afforded to him by the manufacturer to examine the work during its progress, as well as the finished product, to satisfy himself that the work is manufactured and finished in accordance with these specifications.

46. All inspection shall be made at the place of manufacture. Tests of material may be made at the expense of the manufacturer if the amount of any particular kind of material is 50 tons or more. If less than 50 tons, the manufacturer shall certify that it is furnished in accordance with this specification; however, if the purchaser desires that a test be made he shall bear the expense of same, unless the material fails to meet the specifications, in which case the manufacturer shall stand the expense of such test. For the rails used in the work the manufacturer, when requested, shall supply the purchaser with a certificate of inspection from the rail manufacturer.

47. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery, and such defective material shall be replaced by the manufacturer at his own expense.

[23] FROG DESIGNS.

Data for laying out Bolted Rigid Frogs, Railbound Manganese Steel Frogs and Solid Manganese Frogs as given below will aid in laying out frogs of different angles and number from those covered by plans submitted by this Committee.

BOLTED RIGID FROGS.

For data for laying out see Plan No. 320.

RAILBOUND MANGANESE STEEL FROGS.

The rules given below for designs of Railbound Manganese Steel Frogs are applicable for all rail sections from 80 lb. per yard up, and from 2⅜ in. to 3 in. width of head. Design A is applicable to all angles of from No. 4 to No. 20, both inclusive. Design B is applicable to angles of from No. 16 to No. 20, both inclusive.

Sections and other details are to conform to those for similar angles shown on Plans 601 to 607, inclusive. Lengths shall conform to A.R.E.A. standard lengths for Bolted Rigid Frogs.

Rules for Laying Out Design A.

Applicable to All Frogs from No. 4 to No. 20, Inclusive.

1. **Heel.**

The heel end of manganese point is placed where the spread between gage lines is 4¾ in.

2. **Heel Block Extension.**

The heel block extension running out from the heel of manganese point between the heel rails to be 23 in. long for frogs Nos. 4, 5 and 6 and 26 in. long for No. 7; above No. 7, the heel extension is to run 6 in. beyond the point where spread between gage lines is 7¼ in. The heel block extension is integral with the manganese body casting on all frogs up to and including No. 15; for frogs No. 16 to No. 20, inclusive, the integral part is made 10½ in. long from the heel of manganese point and a separate heel block casting forms the balance. The riser at the end of all heel blocks is to have a slope from ½ in. below the level of the head of rails at the end to tread level in a length of 6 in.

3. **Heel Rails.**

The heel rails are offset horizontally toward the gage line by a short bend at the end of the heel block extension and a reverse bend

---

[23] Adopted, Vol. 22, 1921, pp. 660. 973.

15½ in. from the point end of the rails on all frogs up to and including No. 15, and 20½ in. from the point end of the rail for frogs No. 16 to No. 20, inclusive, so as to bring the center line of web ⅞ in. (+ 1/16 in.) from gage line of frog and running parallel to gage line from point end to reverse bend. Head on gage line is planed to straight line conforming to side contour of head. Back of head is planed to a straight taper with a vertical side from 1½ in. net width of head at point to full section at end of heel block extension.

The point end of rail is cut at an angle of 45 deg. to the gage line and the back of head at point end is rounded by 5 in. radius.

4. Wing Rail.

Wing rail laps heel rail from point end to reverse bend or for a length of 15½ in. for all frogs up to and including No. 15, and 20½ in. for No. 16 to No. 20, inclusive, and is parallel to gage line with a width of flangeway of 2¼ in. using a standard section filler made for a 1¾ in. flangeway with full rail heads, but producing a width of 2¼ in. between the line of head of wing rail and the planed away head of heel rail. The side of the head of wing rail is planed for a straight flare on the guard side running on a line from the 1¾ in. width flangeway opposite to a 2¼ in. spread of the gage lines (except for No. 4 and No. 5 frogs) to a 3½ in. flare opening at the end of a flare measured ⅝ in. below tread level. The side of flare planing on the wing rail commencing at the end of the manganese wing to be on a bevel of 25 deg. from vertical. For No. 4 and No. 5 frogs the beginning of the flare line is placed at opposite spread between gage line of 1⅝ in. instead of 2¼ in.

Where the flare line intersects the side of the head of wing rail at the 2¼ in. width of flangeway measured ⅝ in. below tread level, head of wing rail is notched to a radius of ⅝ in. for the reception of the manganese steel wing and rail is bent outward on a straight line so as to bring side of full head 4 in. from gage line opposite theoretical point. Opposite theoretical point wing rail is bent back on a line running to a gage line toe spread of 3 in., but on an angle of not less than 1 in 8 with gage line (frogs No. 4 to No. 10, inclusive). If angle comes out smaller than 1 in 8, reduce toe spread (2.91 in. for No. 11 frog and 2.67 in. for No. 12 frog) to make the angle 1 in 8 until a minimum toe spread of 2½ in. is reached (frogs No. 14 to No. 20, inclusive) when such minimum spread and minimum angle of 1 in 8 are kept and the middle bend of wing rail moved toward the toe end of the frog by extending the line of wing rail running from the notch to the point 4 in. out at theoretical point until such line meets the line drawn from 2½ in. toe spread on the 1 in 8 angle. Head is planed with vertical side from notch to full section of head at middle bend.

5. Manganese Steel Body and Wings.

From the heel end of the manganese point at the 4¾ in. spread the manganese is carried across the flangeway on an angle of 30 deg. to the gage line to the web of the wing rail. It then follows the web of bent wing rail to the bend at toe, where the manganese body ends. The back of the manganese wing fits into the notch in the wing rail and follows the planed and bent head of the wing rail to the toe end, where it lies up against the side of the full head section of the wing rail, the end being sloped and rounded. Manganese wing is flared to follow flare line from 1¾ in. width of flangeway to 2¼ in. opening at notch to meet flare planed in wing rail. Bottom bearing of the manganese steel casting on top of base of wing rail to be continuous throughout except at bends. Bearing under head and against web of wing rail to be 3 in. long at every other through bolt commencing with the second bolt from the manganese heel towards the toe down to the first bolt from the theoretical point towards the heel and then at every bolt to the toe end; and for a length of 4 in. at the last bolt through the toe end of manganese body.

Heel extension to have continuous bearing on the top of base of heel rails and to bear against the web and under head continuous from the point end of heel rails for same length as flangeway filler, then for 3 in. at each bolt beyond end of filler and 4 in. at end of heel block extension.

6. Fillers and Toe Blocks.

Fillers between heel rails and wing rails are of a constant length of 14¼ in. for frogs No. 4 to No. 15, inclusive, and 19¼ in. for frogs No. 16 to No. 20, inclusive, measured on gage line, being cut on an angle of 30 deg. to correspond to angle of manganese steel body carried across flangeway and square on outer end, except when wing rails are beveled, when filler is cut flush with end of the same angle as the wing rail.

Toe blocks are placed 2 in. from the toe end of the manganese body and are 7 in. long, with one bolt for all frogs up to and including No. 15, and 12 in. long with two bolts for frogs No. 16 to No. 20, inclusive.

7. Bolt Spacing.

At heel end spacing of bolts through heel rails, wing rails and fillers is constant; 3 in.-5 in.-5 in. for all frogs from No. 4 to No. 15, inclusive, and 3 in.-5-in.-5 in.-5-in. for frogs No. 16 to No. 20, inclusive, measured on gage line from point end of heel rail. Bolt at end of heel block extension is placed 2 in. from extreme end of all frogs. In 26 in. long heel block extension one additional bolt is placed midway between end bolt and last bolt through filler (No. 7 and No. 8 frogs). In longer extensions (No. 9 frog and above) first bolt outside of end of wing rails is placed 6½ in. from last bolt through flangeway fillers and additional bolts (No. 11 frog and above) are spaced between this bolt and the end bolt in least number of equal spaces not exceeding 10 in. from c. to c. At toe end position of bolts through toe block is constant, being 6 in. measured on gage line from toe end of manganese body for 7 in. toe block and 4 in.-8 in. for 12 in. toe block. Position of first two bolts through manganese body at toe end is constant 2 in.-7 in. for all frogs, measured on gage line from toe end of casting. Body bolts between fixed position of bolts at heel and toe ends are spaced in least number of equal spaces not exceeding 12 in. from c. to c.

Rules for Laying Out Design B

Applicable to All Frogs from No. 16 to No. 20, Inclusive.

The rules for the laying out of Design B are the same as given for Design A for frogs No. 16 to No. 20, inclusive, with the following modifications:

8. Heel.

The heel end of manganese point is placed where the spread between gage lines is 4¼ in. instead of 4¾ in.

9. Heel Block Extension.

To correspond with rules for Design A.

10. Heel Rails.

To correspond with rules for Design A.

11. Wing Rail.

To correspond with rules for Design A, from heel down to opposite theoretical point at 4 in. out from gage line. The wing rail is then bent back on a straight line to meet guard line at opposite the point where the toe spread between gage line is 1 in. (equals 2½ in. wide throat). Angle of this line with guard line to be not smaller than 1 in 8 (1 in 7.1 for No. 16 frog). In No. 18 and No. 20 frogs run line on angle of 1 in 8 from guard line from opposite the 1 in. toe spread and extend line of wing from notch to 4 in. from gage line at theoretical point until the two lines meet. Toe end of manganese wing is placed at opposite the 1 in. toe spread. Wing rail then follows a straight line through throat to a 2⅛ in. spread between gage line, where it is again bent to the line of the frog angle.

12. Manganese Steel Body and Wings.

To correspond with rules for Design A, commencing at the 4¼ in. heel spread to toe end of manganese wing at throat. Manganese body is extended beyond end of manganese wing toward toe as a filler between wing rails a distance of 10 in. with continuous bearing on top of base and under head and against web of rail from toe end of casting to second bolt through manganese wing.

13. Flangeway Fillers and Toe Blocks.

Fillers between heel rail and wing rail same as Design A. Toe blocks are placed 2 in. from end of manganese steel body—1 block 20 in. long for No. 16 frog—2 blocks 2 in. apart, outer one 16 in. long—inner one 6 in. long for No. 18 frog; and 2 blocks 2 in. apart—outer one 16½ in. long—inner one 9½ in. long for No. 20 frogs.

14. Bolt Spacing.

Rules for bolt spacing at the heel and heel block extension are the same as for Design A.

At the toe end the position of the first four bolts through the manganese steel body is constant: 2 in-5 in.-6 in.-7 in. from end of body extension between wing rails. Bolts through toe block are spaced as follows: From first toe bolt through manganese body towards toe end of frog—No. 16 frog, 8 in.-12 in.; No. 18 frog, 7 in.-7 in.-12 in.; No. 20 frog, 8¾ in.-9 in.-12 in.

Body bolts between fixed position of bolts at heel and toe ends are spaced in the least number of equal spaces not exceeding 12 in. from c. to c. same as Design A.

SOLID MANGANESE STEEL FROGS.

The rules given below for the design of solid manganese steel frogs are applicable to all frogs from a No. 4 to a No. 20, inclusive, and for all connecting rail sections from 80 lb. per yard up, and from 2⅜ in. to 3 in. (inclusive), width of head.

Abbreviations and Definitions: Base=Base of rail connecting frog; Head=Head of rail connecting frog; Minimum Width of Head=width of head of rail at a point ⅝ in. below top; Design 1=Type of frog without easer extensions; Design 2=Type of frog with easer extensions.

Sections shall conform to those shown on Plans 651 to 655, inclusive.

Typical details of heel-end, toe-ends and flare are appended.

Grouping of Rails. To establish a minimum of different standard lengths of frogs, rails are grouped as follows, and composite standard lengths for each group tabulated as per appended tables of "Standard Dimensions."

Class "A"—Rail with a base of 5¾ in. down, but not including 5½ in. and head 2⅞ in. to 2⅝ in. wide, inclusive; or rail head at or exceeding 2⅞ in. when head and base do not exceed 8⅝ in.

Class "B"—Rails with a base of 5½ in. down, but not including 5¼ in. and head $2\frac{13}{16}$ in. to $2\frac{9}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{13}{16}$ in. when head and base do not exceed $8\frac{5}{16}$ in.

Class "C"—Rails with a base of 5¼ in. down, but not including 5 in. and head $2\frac{11}{16}$ in. to $2\frac{7}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{11}{16}$ in. when head and base do not exceed $7\frac{15}{16}$ in.

Class "D"—Rails with a base of 5 in. down, but not including 4½ in. and head $2\frac{11}{16}$ in. to $2\frac{7}{16}$ in. wide, inclusive; or rail head at or exceeding $2\frac{11}{16}$ in. when head and base do not exceed $7\frac{11}{16}$ in.

1. Lengths. (General Rule.)

For Design 1, Toe Lengths. Toe Lengths from theoretical ½ in. point = (maximum base minus minimum width of head plus ½ in.) times frog number. Minimum toe length for 15 in. maximum splicing = 2¼ in. times frog number plus 13 in. (below a No. 11 frog, class "A"; a No. 12 frog, class "B"; a No. 14 frog, class "C," and a No. 18 frog, class "D").

For Design 2, Toe Lengths. Toe Lengths from theoretical ½ in. point = (maximum base minus minimum width of head plus ½ in.) times frog number. Minimum toe length = 2¼ in. times frog number plus 6 in. (below a No. 5 frog, class "A"; a No. 6 frog, class "B"; a No. 7 frog, class "C," and a No. 8 frog, class "D").

For Designs 1 and 2, Heel Lengths. Heel Lengths from theoretical ½ in. point = (maximum base plus maximum width of head minus ½ in.) times frog number. Minimum heel length for 15 in. maximum splicing and 15 in. length of flare = 3 ft. 6 in. (frogs Nos. 4 and 5 all classes).

All lengths to be taken to the even inch (lower for fractions up to but not including ½ in., higher for fractions ½ in. or more).

2. Heights.

Heights of frog casting to be (both designs):

4⅝ in. high for connecting rails of 4⅜ in. to $4\frac{11}{16}$ in. high, inclusive.
5 in. high for connecting rails of 4¾ in. to $5\frac{1}{16}$ in. high, inclusive.
5⅜ in. high for connecting rails of 5⅛ in. to $5\frac{7}{16}$ in. high, inclusive.
5¾ in. high for connecting rails of 5½ in. to $5\frac{13}{16}$ in. high, inclusive.
6⅛ in. high for connecting rails of 5⅞ in. to $6\frac{3}{16}$ in. high, inclusive.
6½ in. high for connecting rails of 6¼ in. to 6⅝ in. high, inclusive.

3. Heel Extension.

Heel extension to run 15 in. beyond heel joint.

For Design 1—Its top to be 1⅝ in. below tread of connecting rails. Easer to be formed in front of heel extension, between tread lines, sloping from ½ in. below at heel joint to flush with tread in 6 in.

For Design 2—Its top to be flush with tread of connecting rails, sloping to ½ in. below tread in 6 in. at extreme end.

Side walls or webs to fit fishing section of connecting rail. End walls to be ¾ in. thick.

4. Toe Extension.

For Design 1—Toe extension to run between rails for 15 in. beyond toe joint. Its top to be level with bottom of flangeway. Side walls or webs to fit fishing section of connecting rail. End wall to be ¾ in. thick. Outside splice bars and through bolts to be used for fastening rails.

For Design 2—Toe extension to run along outside of connecting rails for 15 in. beyond toe joint, forming easer; and fitting outside section of connecting rails. Its top to be flush with tread of connecting rail, sloping to ½ in. below tread in 6 in. at extreme end. Vertical web of extension to be flush with outside and ⅞ in. thick. Method of fastening toe rails by toe block and through bolts or direct independent bolting or supplementary tie plate, optional with manufacturer.

5. Width of Tread Surface.

Width of tread surface to vary with height of frog casting:

DESIGN 1.

2½ in. wide for 4⅝ in. high frog casting.
2⅝ in. wide for 5 in. and 5⅜ in. high frog casting.
2¾ in. wide for 5¾ in. high frog casting.
2⅞ in. wide for 6⅛ in. high frog casting.
3 in. wide for 6½ in. high frog casting.

DESIGN 2.

4 in. wide for 4⅝ in., 5 in. and 5⅜ in. high frog casting.
4½ in. wide for 5¾ in., 6⅛ in. and 6½ in. high frog casting.

6. Flare and Side Lines of Frog.

For Design 1—Carry full width of tread surface (see rule 5) from toe end to opposite theoretical ½ in. point, following gage, throat and guard lines.

For Design 2—Carry outer line of tread surface (see rule 5) from toe end, including toe extension, parallel to gage line to opposite theoretical point.

Then (for both designs) taper width to 1¼ in. wide guard for 1¾ in. wide flangeway, at a point opposite beginning of flare. Flare begins where spread of gage lines is 2¼ in. (except frogs Nos. 4, 5, 6, all classes, and No. 7, class "D"), and runs to a 2½ in. opening in 10 in. and then in 6 in. to a 3¾ in. opening at the end. If this brings end of flare (16 in. from point of commencement) opposite a point where spread of gage lines is less than 4 in. (above a No. 9 frog), then extend flare by placing outside end at the 4 in. spread, go back 6 in. reducing opening from 3¾ in. at extreme to 2½ in. in that distance, same as on wide end of the normal standard flare, then reduce width of opening by a straight line from the 2½ in. to the regular 1¾ in. width of flangeway at the point where spread of gage lines is 2¼ in.

NOTE.—For flangeways wider than 1¾ in. the length of flare will be shortened correspondingly.

If end of flare comes closer than 23$\frac{5}{16}$ in. from heel joint, reduce 10 in. portion of the normal standard flare to a length of 6 in. and relocate end of flare at 23$\frac{5}{16}$ in. from heel joint (for frogs Nos. 4, 5, 6, all classes, and No. 7, Class "D").

7. Joint Surfaces at Heel End.

Run web lines parallel to gage line for a length of 17 in., round off with a 3¾ in. radius to a 45 deg. line joining the regular outer wall. (Both designs.)

8. Joint Surface at Toe End.

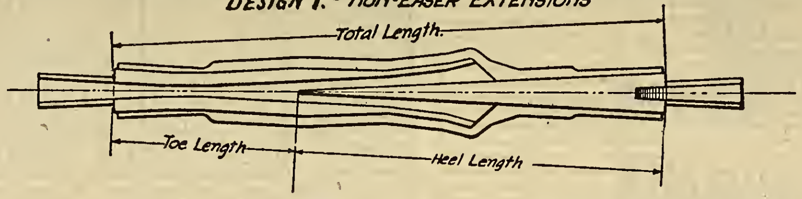
Design 1 only—Run web line from toe joint parallel to gage line without regard to top line for a length of 17 in., round off with a 3¾ in. radius to a 45 deg. line joining the regular outer wall. If this would bring outer web line closer than ¾ in. to guard line at throat, reduce joint surface from 17 in. long to necessary shorter length to make wall ¾ in. thick (Nos. 4 and 5 frogs).

9. Bolts at Joints.

Bolt spacing at joints to agree with purchaser's specifications. Bolts to be of high tensile steel. Bolt holes to be ¼ in. larger diameter than diameter of bolts specified by purchaser. Through bolts in heel of designs 1 and 2 and toe of Design 1 to have ⅜ in. minimum to ⅝ in. maximum thick metal around bolt, extending from web to web of section.

STANDARD DIMENSIONS OF SOLID MANGANESE STEEL FROGS

DESIGN 1. - NON-EASER EXTENSIONS



USE TABLE GIVING SHORTEST LENGTHS THAT WILL APPLY IN EACH CASE.

A.	B.	C.	D.
Rail base $5\frac{3}{4}''$ down but not incl. $5\frac{1}{2}''$. Rail head $2\frac{7}{8}''$ to $2\frac{5}{8}''$ incl. Or rail head at or exceeding $2\frac{7}{8}''$ when head and base do not exceed $8\frac{5}{8}''$	Rail base $5\frac{1}{2}''$ down but not incl. $5\frac{1}{4}''$. Rail head $2\frac{13}{16}''$ to $2\frac{9}{16}''$ incl. Or rail head at or exceeding $2\frac{13}{16}''$ when head and base do not exceed $8\frac{5}{16}''$.	Rail base $5\frac{1}{4}''$ down but not incl. $5''$. Rail head $2\frac{11}{16}''$ to $2\frac{7}{16}''$ incl. Or rail head at or exceeding $2\frac{11}{16}''$ when head and base do not exceed $7\frac{15}{16}''$.	Rail base $5''$ down but not incl. $4\frac{1}{2}''$. Rail head $2\frac{11}{16}''$ to $2\frac{7}{16}''$ incl. Or rail head at or exceeding $2\frac{11}{16}''$ when head and base do not exceed $7\frac{11}{16}''$.

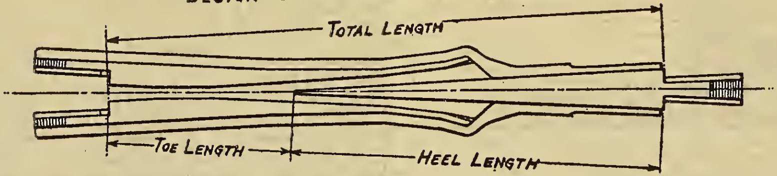
Frog No.	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length
4	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"	3'-6"	1'-10"	5'-4"
5	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"
6	4'-1"	2'-3"	6'-4"	3'-11"	2'-3"	6'-2"	3'-9"	2'-3"	6'-0"	3'-7"	2'-3"	5'-10"
7	4'-9"	2'-5"	7'-2"	4'-7"	2'-5"	7'-0"	4'-4"	2'-5"	6'-9"	4'-2"	2'-5"	6'-7"
8	5'-5"	2'-7"	8'-0"	5'-3"	2'-7"	7'-10"	5'-0"	2'-7"	7'-7"	4'-10"	2'-7"	7'-5"
9	6'-1"	2'-9"	8'-10"	5'-10"	2'-9"	8'-7"	5'-7"	2'-9"	8'-4"	5'-5"	2'-9"	8'-2"
10	6'-9"	3'-0"	9'-9"	6'-6"	3'-0"	9'-6"	6'-2"	3'-0"	9'-2"	6'-0"	3'-0"	9'-0"
11	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-2"	10'-0"	6'-7"	3'-2"	9'-9"
12	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-4"	10'-6"
14	9'-6"	4'-3"	13'-9"	9'-1"	4'-0"	13'-1"	8'-8"	3'-10"	12'-6"	8'-5"	3'-9"	12'-2"
15	10'-2"	4'-6"	14'-8"	9'-9"	4'-4"	14'-1"	9'-4"	4'-2"	13'-6"	9'-0"	3'-11"	12'-11"
16	10'-10"	4'-10"	15'-8"	10'-5"	4'-7"	15'-0"	9'-11"	4'-5"	14'-4"	9'-7"	4'-1"	13'-8"
18	12'-2"	5'-5"	17'-7"	11'-9"	5'-2"	16'-11"	11'-2"	5'-0"	16'-2"	10'-9"	4'-7"	15'-4"
20	13'-7"	6'-1"	19'-8"	13'-0"	5'-9"	18'-9"	12'-5"	5'-6"	17'-11"	12'-0"	5'-1"	17'-1"

A	110 L.V. 105 DUD.	100 A.S.C.E 100 DUD. 100 I.R.T.	95 B&A.			
B	107 N.H. 101 D.L.&W.	100 N.H. 100 A.R.A."A" 100 P.R.R. 100 P.&R. 100 A.R.E.A	90 A.S.C.E. 90 U.P. 91 D.L.&W. 90 N.H.			
C		100 A.R.A."B" 100 C.&N.W.	90 A.R.A."A" 90 A.T.&S.F. 90 D.&R.G. 90 P.&R. 90 I.R.T.	85 A.S.C.E. 85 C.B.&Q. 85 MO.PAC. 85 D.&R.G.		
D		100 P.S.Penn 100 I.S.Co.	90 A.R.A."B" 90 G.NOR. 90 DUD.	85 P.S.Penn 85 P.R.R. 85 G.NOR. 85 N.Y.C.&S.L. 85 CAN.PAC. 85 SOO LINE 85 S.A.L. 85 D.&R.G.&C.&S. 85 DUD.	80 A.R.A."A" 80 A.S.C.E 80 DUD. 80 CAN.NOR 80 H.V. 80 CAN #540	

NOTE: FIGURES ABOVE THE HEAVY LINES ARE MINIMUM LENGTHS.

STANDARD DIMENSIONS OF SOLID MANGANESE STEEL FROGS

DESIGN-2 — EASER EXTENSIONS.

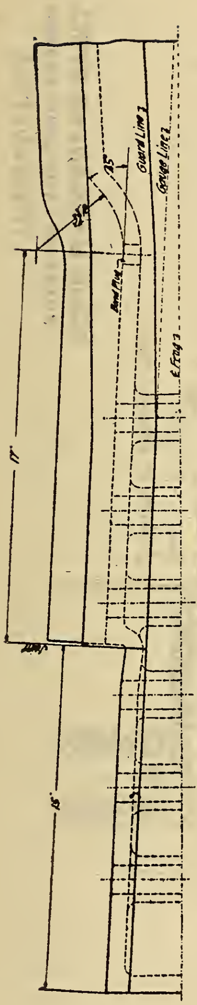


USE TABLE GIVING SHORTEST LENGTHS THAT WILL APPLY IN EACH CASE.

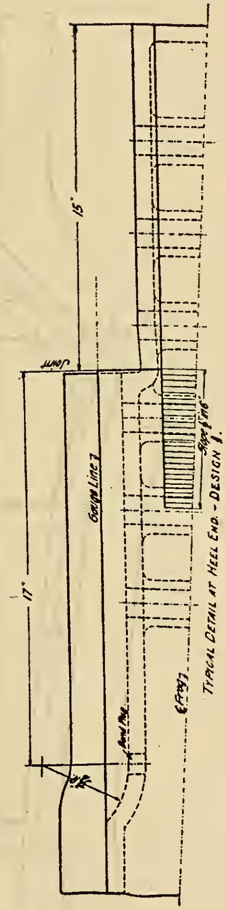
	A			B			C			D		
	Rail Base 5¾" Down But Not Incl. 5½". Rail Head 2⅞" To 2⅝" Incl. Or Rail Head At Or Exceeding 2⅞" When Head And Base Do Not Exceed 8⅝".			Rail Base 5½" Down But Not Incl. 5¼". Rail Head 2 13/16" To 2 9/16" Incl. Or Rail Head At Or Exceeding 2 13/16" When Head And Base Do Not Exceed 8 5/16".			Rail Base 5¼" Down But Not Incl. 5". Rail Head 2 11/16" To 2 7/16" Incl. Or Rail Head At Or Exceeding 2 11/16" When Head And Base Do Not Exceed 7 15/16".			Rail Base 5" Down But Not Incl. 4½". Rail Head 2 11/16" To 2 7/16" Incl. Or Rail Head At Or Exceeding 2 11/16" When Head And Base Do Not Exceed 7 11/16".		
Frog No.	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length	Heel Length	Toe Length	Total Length
4	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"	3'-6"	1'-3"	4'-9"
5	3'-6"	1'-6"	5'-0"	3'-6"	1'-5"	4'-11"	3'-6"	1'-5"	4'-11"	3'-6"	1'-5"	4'-11"
6	4'-1"	1'-10"	5'-11"	3'-11"	1'-9"	5'-8"	3'-9"	1'-8"	5'-5"	3'-7"	1'-8"	5'-3"
7	4'-9"	2'-1"	6'-10"	4'-7"	2'-0"	6'-7"	4'-4"	1'-11"	6'-3"	4'-2"	1'-10"	6'-0"
8	5'-5"	2'-5"	7'-10"	5'-3"	2'-4"	7'-7"	5'-0"	2'-3"	7'-3"	4'-10"	2'-1"	6'-11"
9	6'-1"	2'-9"	8'-10"	5'-10"	2'-7"	8'-5"	5'-7"	2'-6"	8'-1"	5'-5"	2'-4"	7'-9"
10	6'-9"	3'-0"	9'-9"	6'-6"	2'-10"	9'-4"	6'-2"	2'-9"	8'-11"	6'-0"	2'-7"	8'-7"
11	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-0"	9'-10"	6'-7"	2'-10"	9'-5"
12	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-1"	10'-3"
14	9'-6"	4'-3"	13'-9"	9'-1"	4'-0"	13'-1"	8'-8"	3'-10"	12'-6"	8'-5"	3'-7"	12'-0"
15	10'-2"	4'-6"	14'-8"	9'-9"	4'-4"	14'-1"	9'-4"	4'-2"	13'-6"	9'-0"	3'-10"	12'-10"
16	10'-10"	4'-10"	15'-8"	10'-5"	4'-7"	15'-0"	9'-11"	4'-5"	14'-4"	9'-7"	4'-1"	13'-8"
18	12'-2"	5'-5"	17'-7"	11'-9"	5'-2"	16'-11"	11'-2"	5'-0"	16'-2"	10'-9"	4'-7"	15'-4"
20	13'-7"	6'-1"	19'-8"	13'-0"	5'-9"	18'-9"	12'-5"	5'-6"	17'-11"	12'-0"	5'-1"	17'-1"

A	110 L.V.	100 A.S.C.E.	95 B.&A.			
	105 DUD.	100 DUD.				
		100 I.R.T.				
B	107 N.H.	100 N.H.	90 A.S.C.E.			
	101 D.L.&W.	100 A.R.A."A."	90 U.P.			
		100 P.R.R.	91 D.L.&W.			
		100 P.&R.	90 N.H.			
		100 A.R.E.A.				
C		100 A.R.A."B."	90 A.R.A."A."	85 A.S.C.E.		
		100 C.&N.W.	90 A.T.&S.F.	85 C.B.&Q.		
			90 D.&R.G.	85 Mo. Pac.		
			90 P.&R.	85 D.&R.G.		
			90 I.R.T.			
D		100 P.S. Penn.	90 A.R.A."B."	85 P.S. Penn.	80 A.R.A."A."	
		100 I.S.Co.	90 Gr. Nor.	85 P.R.R.	80 A.S.C.E.	
			90 DUD.	85 Gr. Nor.	80 DUD.	
				85 N.Y.C.&S.L.	80 Can. Nor.	
				85 Can. Pac.	80 H.V.	
				85 Soo Line	80 Cam. #540	
				85 S.A.L.		
				85 D.&R.G.&C.&S.		
				85 DUD.		

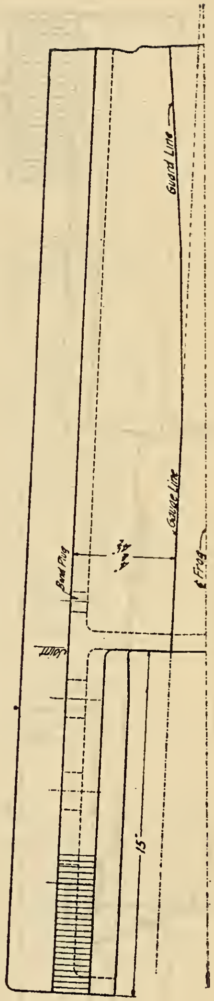
NOTE: FIGURES ABOVE THE HEAVY LINES ARE MINIMUM LENGTHS.



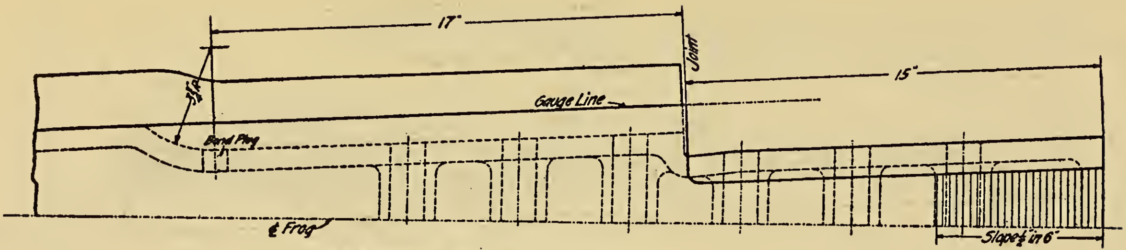
TYPICAL DETAIL AT TOE END:- DESIGN 1.



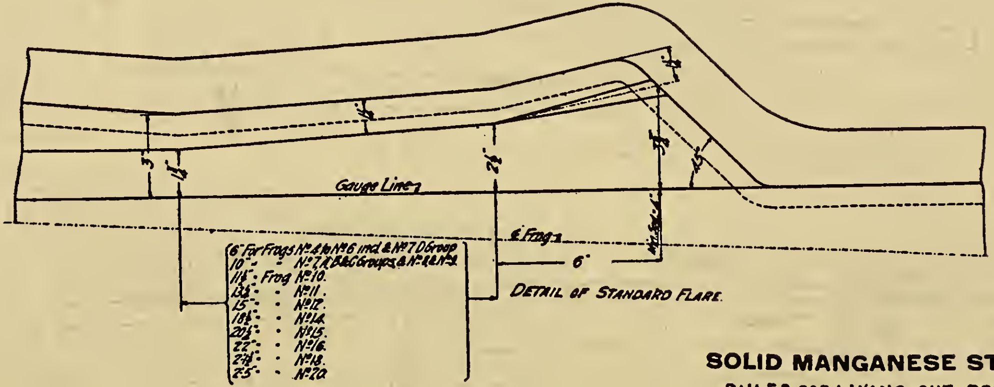
TYPICAL DETAIL AT HEEL END. - DESIGN 1.



TYPICAL DETAIL AT TOE END - DESIGN 2.



Typical Detail at Heel End.– Design 2.



Detail of Standard Flare.

SOLID MANGANESE STEEL FROG

RULES FOR LAYING-OUT DESIGNS 1 AND 2.

TYPICAL DETAILS.

[26] SPECIFICATIONS FOR THE DESIGN AND DIMENSIONS OF MANGANESE STEEL POINTED SWITCHES

1. Manganese steel pointed switches shall consist of rolled rail with the head cut away for a portion of the point and the manganese steel tip set thereon and attached to and supported by the web and base of the switch rail.

2. The manganese steel tip shall have an integral extension, or tail piece, running from the surface joint between the manganese steel and the rail, into the fishing section of the switch rail, minimum length of such tail piece to be 10-inch and minimum thickness ¾-inch, thickened to at least 1 in. at surface joint.

3. A reinforcing strap not less than ⅜-inch thick, fitting the fishing section, shall be provided on the opposite side of the web of the rail, extending along the full length of the manganese steel tip and beyond the end of the side head planing of the switch rail.

4. The top of the surface joint, between the manganese steel and the rolled rail, shall be at least ⅛-inch below the head of the stock rail. Where the stock rail is worn considerably a new stock rail should be installed with a new switch point to assure the joint between the manganese tip and the rolled rail coming below the running surface.

5. The end of the point shall be 12-inch below the top of the stock rail and rounded off with a radius of 1½ in. It shall be shaped by grinding from a theoretical distance of 5/16-inch, between gage lines, to a thickness of 1/16-inch on the top line. A depth of 1⅞-inch, measured from the top of the stock rail, shall be provided for clearance of the wheel flanges, on any parts of the manganese steel or reinforcing bars projecting below the path of the wheel flange.

6. The thickness of the vertical member of the manganese steel tip adjacent to the rail web shall be minimum of 9/16-inch at the point, increasing towards the joint.

7. The minimum length of the manganese steel tips, measured from the actual point to the surface joint on the gage line, shall be 2 ft. 0 in. for switches from 10 ft. 0 in. to 12 ft. 0 in. in length, inclusive, and 2 ft. 6 in. for all switches over 12 ft. 0 in. long, used under ordinary conditions. On curved switches, or under special conditions of severe side wear, longer tips may be required. Variations from the lengths recommended may also be required by rod and tie spacing in individual cases.

[27] REQUISITES FOR SWITCH STANDS, INCLUDING CONNECTING RODS.

1. Provision shall be made for spiking or bolting switch stands to two head blocks.

---

[26] Adopted, Vol. 21, 1920, pp. 188, 1369.
[27] Adopted, Vol. 22, 1921, pp. 674, 973.

2. Classification of Switch Stands according to Heights. (Note.—Height of Switch Stands is measured from top of tie to bottom of taper of lamp tip):

A. High Switch Stands:

Height greater than	14′ 0″
Standard height	18′ 0″

B. Intermediate Switch Stands:

Height greater than	2′ 0″
To and including	14′ 0″
Standard Heights:	
(a) First Intermediate	7′ 9″
(b) Second Intermediate	6′ 0″
(c) Third Intermediate	4′ 0″

C. Low Switch Stands:

Height greater than	1′ 0″
To and including	2′ 0″

D. Extra Low Switch Stands:

Height	1′ 0″ or less

Note.—Extra low switch stands are for general use with target lamps without separate targets.

3. The operating lever of extra low and low switch stands shall work parallel with the track.

4. The switch stand shall be so arranged that it can easily be inspected.

5. There shall be no lost motion in the bearings. The connections between the various parts of the switch stand shall be such as to insure against movement of switch points without corresponding movement of the operating lever.

6. The connection between the connecting rod and the switch stand shall be by a turned bearing of not less than 1⅛ in. diameter, and shall be so arranged that separation cannot occur under operating conditions.

7. Provision shall be made for adjusting the throw of either or both switch points without moving the switch stand.

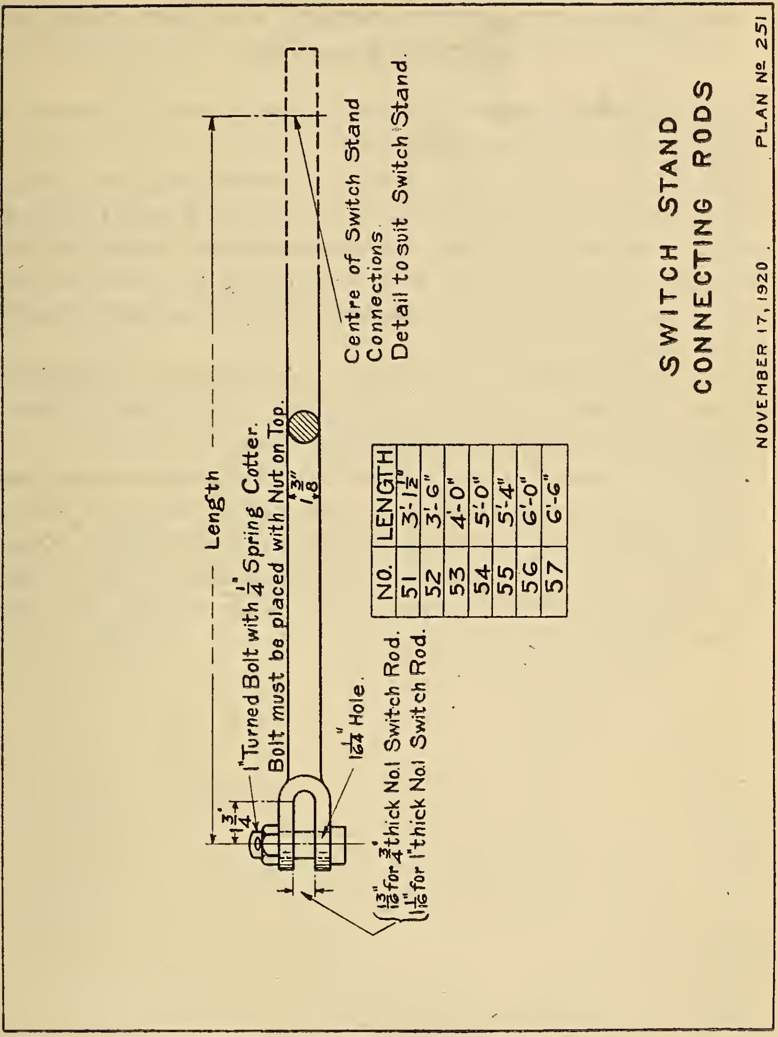
8. The throwing apparatus shall be so arranged that it will lock or latch in either extreme position without the use of the switch lock.

9. Lengths and details of connecting rods shall conform to plan No. 251, dated November 17th, 1920.

10. The target and lamp tip when used on a switch stand shall revolve through 90 degrees with the movement of the switch points, and indicate their position.

11. Shapes and sizes of targets shall conform to plan..............

12. Lamp tips shall conform to plan......


Length
1" Turned Bolt with 1/4" Spring Cotter.
Bolt must be placed with Nut on Top.
1 3/8"
Centre of Switch Stand Connections.
Detail to suit Switch Stand.
1 3/4"
1 1/64" Hole.
13/16" for 3/4" thick No. 1 Switch Rod.
1 1/16" for 1" thick No. 1 Switch Rod.

NO.	LENGTH
51	3'-1 1/2"
52	3'-6"
53	4'-0"
54	5'-0"
55	5'-4"
56	6'-0"
57	6'-6"

SWITCH STAND
CONNECTING RODS

NOVEMBER 17, 1920. PLAN No. 251

On account of the variety in the detail of switch stands now on the market and the fact that many of the features are patented, the Committee recommends that it would not be desirable to prepare plans nor complete specifications for switch stands, and in lieu thereof recommends the above. The requisite of switch stands have been drawn sufficiently broad to include the more efficient and complete switch stands now commercially available.

[28] DESIRABLE AGENCIES TO OBTAIN A BETTER CLASS OF SECTION FOREMEN.

The following principles are recommended as desirable agencies to secure a better class of section foremen:

(1) The application of the principle of apprenticeship for a defined period during which the rate of pay shall be the same as that of a laborer, and following which those men who show the necessary qualities for foremen shall be given an increase in compensation and the title of assistant foreman. From this position these men should be promoted to that of section foreman.

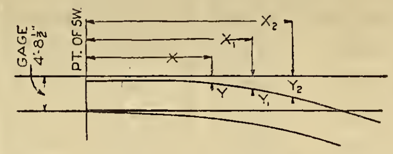
(2) The application of a method of education which contemplates periodical meetings, at which supervising officers shall instruct concerning practice and shall encourage discussion among the men.

(3) The application where possible of an educational system, such as is in use on several of the larger railways. In this system articles dealing with the best practices are written by supervising officers and are printed and sent to foremen and assistant foremen free of cost. Later an examination is conducted on the results of which promotion depends.

---

[28] Adopted, Vol. 14, 1913, pp. 108-109, 130, 1058, 1059.

[29] TABLE OF PRACTICAL TURNOUT LEADS



Frog Number	Length of Switch Rail	Lead = Distance Actual Point of Switch Rail to Frog ½ in. Point	Closure Rails: Number of Rails and Lengths in Feet and Inches: Straight Rail	Closure Rails: Curved Rail	Lead Curve: Radius of Center Line	Lead Curve: Degree of Curve	Gage Line Offsets: X	X1	X2	Y	Y1	Y2	Tangent Adjacent to Switch Rail	Tangent Adjacent to Toe of Frog
	Ft. In.	Ft. In.			Feet	Deg. Min. Sec.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In	.Ft.	Ft.
5	11-0	42-6½	1—28-0	1—28-3¾	175.40	33-07-28	17-11	24-10	31-9	0-11⅝	1- 8 5/16	2- 8 5/16	0.00	0.97
6	11-0	47-6	1—32-9	1—33	254.00	22-42-20	19- 2¼	27- 4½	35-6¾	1- 0 5/16	1- 9½	2- 9 15/16	0.00	2.00
7	16-6	62-1	1—26 1—14-10½	1—26 1—15-1½	361.69	15-53-30	26- 8½	36-11	47-1½	0-11¾	1- 8 11/16	2- 9⅛	0.00	0.22
8	16-6	68-0	1—30 1—16-5	1—30 1—16-7	487.37	11-46-36	28- 1¼	39- 8½	51-3¾	1- 0 1/16	1- 9 3/16	2- 9⅝	0.32	0.00
9	16-6	72-3½	1—33 1—16-5	1—33 1—16-7	605.18	9-28-42	28- 9	40-11¾	53-2¼	1- 0¼	1- 9⅛	2- 9	0.00	0.57
10	16-6	78-9	1—28 1—27-10	2—28	779.82	7-21-08	30- 3⅜	44- 0⅝	57-9¾	1- 0 7/16	1- 9 7/16	2- 9⅜	1.56	0.00
11	22-0	94-3¾	1—33 1—32-10¼	2—33	922.65	6-12-47	40- 8⅞	56- 5⅝	72-2¼	1- 0 15/16	1-10 1/16	2-10 7/16	2.99	0.00
12	22-0	100-9⅝	2—24 1—23-10⅝	3—24	1098.73	5-12-59	43-11⅞	60- 7¾	77-3⅜	1- 1 13/16	1-10 13/16	2-10 15/16	5.33	0.00
14	22-0	106-3¼	2—30 1—16-5¼	2—30 1—16-6¾	1512.14	3-47-23	41- 1¼	60- 2½	79-3¾	1- 0 15/16	1-10½	2-10 15/16	0.00	2.84
15	30-0	126-2¼	2—30 1—27-10¾	2—30 1—28	1748.29	3-16-40	52- 0	74- 0	96-0	1- 0 5/16	1- 9 11/16	2-10⅜	0.00	0.51
16	30-0	131-6¾	2—30 1—32-10¾	2—30 1—33	2019.18	2-50-16	53- 2¾	76- 5½	99-8¼	1- 0½	1- 9 15/16	2-10⅝	0.00	0.40
18	30-0	138-6	2—33 1—32-11	3—33	2380.47	2-24-26	54- 8¾	79- 5½	104-2¼	1- 0¾	1-10 5/16	2-10 15/16	0.00	6.38
20	30-0	151-5½	2—33 1—30 1—14-11½	2—33 1—30 1—15-0½	3322.13	1-43-29	57-9	85-6	113.3	1- 1 3/16	1-10 15/16	2-11 7/16	0.00	0.27

TURNOUTS AND CROSSOVERS RECOMMENDED
For Main Line High Speed Movements, No. 16 or No. 20.
For Main Line Slow Speed Movements, No. 12 or No. 10.
For Yards and Sidings, to Meet General Conditions, No. 8.

Note.—When conditions require a wider gage than 4 ft. 8½ in., the length lead as shown for 4 ft. 8½ in. gage shall be maintained and the gage widened on the inside rail back of the heel of switch.

---

[29] Adopted, Vol. 22, 1921, pp. 672, 673, 973.

TABLE OF THEORETICAL TURNOUT LEADS

PROPERTIES OF FROGS							PROPERTIES OF SWITCHES		LEADS For P. C. at Heel of Switch and P. T. at Toe End of Frog			THEORETICAL LEADS For Uniform Curve Throughout		
Frog Number	Total Length	Toe Length to ½ in. Point	Heel to ½ in. Point	Frog Angle	Toe Spread	Heel Spread	Length of Switch Rail	Thickness of Point = ¼ in. Heel Spread = 6¼ in. Switch Angle	Radius of Center Line	Degree of Curve	Distance Point of Switch to Theoretical Point of Frog	Radius of Center Line	Degree of Curve	Distance P. C. to Theoretical Point of Frog
	Ft.In.	Ft. In.	Ft. In.	Deg.Min.Sec.	In.	In.	Ft. In.	Deg.Min.Sec.	Feet	Deg.Min.Sec.	Feet	Feet	Deg.Min.Sec.	Feet
5	9–0	3– 6½	5– 5½	11–25–16	$7\frac{15}{16}$	$13\frac{9}{16}$	11–0	2–36–19	185.59	31–15–28	42.94	235.42	24–31–28	47.08
6	10–0	3– 9	6– 3	9–31–38	7	13	11–0	2–36–19	280.48	20–32–14	48.41	339.08	16–57–34	56.51
7	12–0	4– 8½	7– 3½	8–10–16	$7\frac{9}{16}$	13	16–6	1–44–11	364.88	15–47–19	61.94	461.43	12–26–30	65.92
8	13–0	5– 1	7–11	7–09–10	7⅛	12⅜	16–6	1–44–11	488.71	11–44–40	67.47	602.65	9–31–06	75.33
9	16–0	6– 4½	9– 7½	6–21–35	$8\frac{1}{16}$	$13\frac{5}{16}$	16–6	1–44–11	616.27	9–18–27	72.24	762.73	7–31–02	84.75
10	16–6	6– 5	10– 1	5–43–29	$7\frac{3}{16}$	12⅝	16–6	1–44–11	790.25	7–15–18	77.51	941.70	6–05–14	94.17
11	17–0	6– 5½	10– 6½	5–12–18	$6\frac{9}{16}$	12	22–0	1–18–08	940.21	6–05–48	92.06	1139.47	5–01–48	103.59
12	18–6	6–11	11– 7	4–46–19	$6\frac{7}{16}$	12⅛	22–0	1–18–08	1136.34	5–02–38	97.25	1355.96	4–13–36	113.00
14	21–6	7–10	13– 8	4–05–27	$6\frac{3}{16}$	$12\frac{3}{16}$	22–0	1–18–08	1600.73	3–34–48	107.16	1845.64	3–06–18	131.83
15	22–6	8– 3½	14– 2½	3–49–06	6⅛	11⅞	30–0	0–57–18	1764.69	3–14–50	125.87	2118.70	2–42–16	141.25
16	24–0	8– 8	15– 4	3–34–47	6	12	30–0	0–57–18	2032.74	2–49–08	131.15	2410.79	2–22–36	150.67
18	26–6	9– 7	16–11	3–10–56	5⅞	11¾	30–0	0–57–18	2632.76	2–10–35	141.18	3051.10	1–52–40	169.50
20	29–0	10– 6	18– 6	2–51–51	$5\frac{13}{16}$	11⅝	30–0	0–57–18	3334.16	1–43–06	150.77	3766.70	1–31–16	188.33

COMMITTEE VI.

BUILDINGS.

[1] DEFINITIONS.

ASHPIT.—A structure into which cinders are deposited from locomotives, for subsequent removal.

COALING STATION.—An established location for the storing and delivering of coal to locomotives.

DROP PIT.—A pit in the track inside of the engine house in which machinery is located for dropping wheels from under locomotives.

ENGINE HOUSE.—A structure for housing and the general maintenance of engines in service.

ENGINE PIT.—A pit in the track inside the engine house to facilitate the repairing and cleaning of the running gear under an engine.

FREIGHT HOUSE.—

Inbound.—A building for the handling of freight for delivery to consignee.

Outbound.—A building for the receiving of freight by the railroad for shipment.

INSPECTION PIT.—A pit in a track approaching an engine house to facilitate the inspection of engines.

OIL HOUSE.—A building for the storage and distribution of oil and waste.

POWER HOUSE.—A building for housing apparatus for generating light, heat and power for various purposes.

REST HOUSE.—A building for the accommodation of employees, usually containing rest and recreation rooms, sleeping quarters, lunch room, lockers, bath, etc.

SECTION TOOL HOUSE.—A building for housing of section cars, tools and small track material.

SHELTER SHED.—

Butterfly Type.—A type of structure erected over platforms for protection from the weather with a central line of supports and roof sloped towards center for drainage.

Umbrella Type.—A type of structure erected over platforms for protection from the weather with a central line of supports and roof sloped to the sides for drainage.

---

[1] Adopted, Vol. 21, 1920, pp. 146, 1362.

SHOP BUILDINGS.—Various structures for the construction and repair of locomotives, cars and other railway equipment.

SMOKE JACK.—A ventilating appliance for taking smoke and gases out of engine houses.

STATION.—An established location for the accommodation of passenger and freight traffic.

TRANSFER PLATFORM (Freight.)—A platform approximately level with freight car floors used in transferring freight from car to car.

TRANSFER TABLE.—A traveling structure with a track on which a locomotive or car can be run and transferred from one parallel track to another.

TURNTABLE.—A revolving structure for turning locomotives or cars.

TURNTABLE PIT.—A circular pit depressed below the surface of the ground in which the turntable revolves.

[2]ASHPITS.

General.

The ashpit is one of the most expensive structures on a railroad from a maintenance standpoint. Therefore, a great deal of thought should be given to the design.

The usual procedure at an ashpit is to drop or wash the hot ashes into the pit, and this heats up the walls and other parts of the structure. Then cold water is thrown on the ashes to cool them. This rapid cooling causes contraction in the material of which the structure is built, and when repeated many times weakens and sometimes destroys the structure.

Another destructive element is the sulphuric acid produced by the water and sulphur in the ashes. This destroys the steel parts (coming in contact with it) at a rapid rate.

Most ashpits are built of concrete, in which limestone is a principal ingredient. Hot ashes cause this limestone to swell and disintegrate, and in a short time the concrete will begin to spall off.

Vitrified brick facing has been used, but on account of the nature of the work and the tools used, experience shows that it is soon knocked off.

Slag and gravel concrete has been used in place of limestone concrete and makes a good substitute. If trap rock is available it makes a better concrete than either of the above materials.

All types of pits should be equipped with water supply to wet down the hot cinders.

To warn and prevent persons from falling into the pit proper, an extension floor should be placed under track at both ends of all pits. This floor to be inclined on a 20 per cent. grade for a length of 15 feet.

---

[2] Adopted, Vol. 18, 1917, pp. 815, 1530.

Where twenty-five (25) or more engines are handled in twenty-four hours, the mechanical handling of cinders is recommended.

Various Types of Pits.

(1) At outlying districts, where few engines are handled, cast-iron ties, approximately 12 inches high, are used to prevent burning wood ties. These should be located on spur tracks.

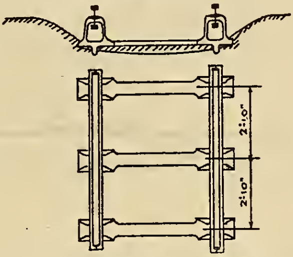


Fig. 1. Cast-Iron Tie Pit.

(2) Pit located between the track rails, of length to suit the business handled. The cinders are shoveled out on the track level and loaded by hand into cars or loaded into barrows and wasted at a convenient place.

These pits are sometimes fitted with buckets which are handled by stationary, traveling or gantry cranes. Where stationary cranes are used, track is placed in the bottom of pit, buckets are equipped with trucks to permit of their being moved to the crane and loaded into cars.

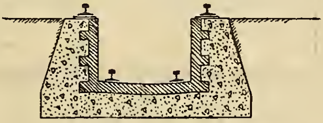


Fig. 2. Track Pit.

(3) Pit similar to Type No. 2, one side open, with depressed track alongside; the relative location of the top of the car with respect to the floor of the pit to be such as to give the easiest shoveling condition.

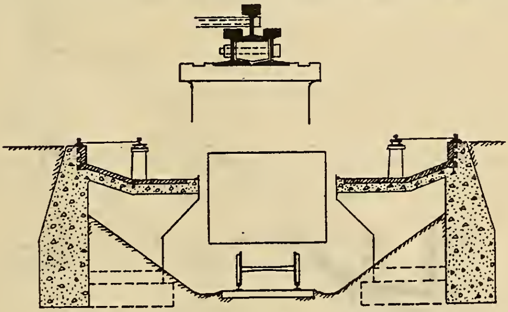


Fig. 3. Depressed Ash Car Track.

(4) Depressed pit filled with water, into which the cinders are dropped. One feature being to design the pit so that cinders will drop directly into the water and reach the main body of the pit freely. Another feature being the easy removal of the cinders by grab bucket operated either by a gantry, traveling or locomotive crane.

Depth of water in pit should not be more than 5 ft. below the drainage outlet.

Railing or iron posts with chains hooked between to be placed around pits, except across tracks where standard clearance diagram is to be followed.

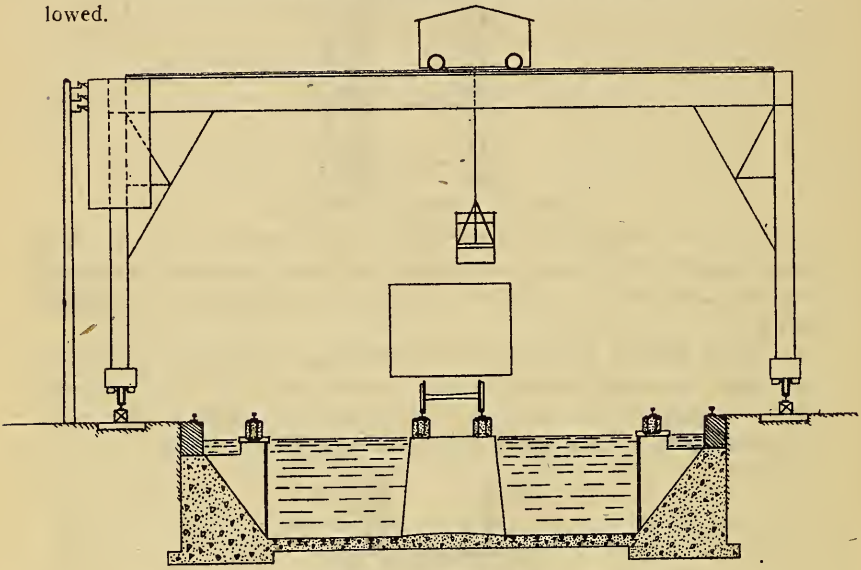


FIG. 4. WATER PIT WITH CRANE AND BUCKET.

(5) Pit equipped with bucket or car located under the track and hoisted by mechanical means, the cinder bucket or car running on rails placed on an incline, car being run high enough to dump in a car located on a track parallel to and approximately 25 ft. centers from ash track.

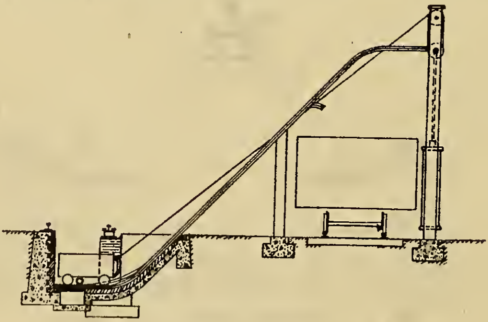


FIG. 5. TRACK PIT WITH BUCKET, POWER OPERATED.

[3] ENGINE HOUSE DESIGN.

(Applicable to New Houses.)

Door Openings.

The clear opening of entrance doors should not be less than thirteen (13) feet in width and sixteen (16) feet in height.

Doors.

Doors should be easily operated, fit snugly, be easily repaired and maintained, and should admit of the use of small doors.

Drop Pits.

Drop pits should be provided for handling truck, driving and trailer wheels.

Electric Lighting.

General distribution of illumination should be provided between pits by arranging a number of lights to avoid shadows and to give good light for workmen at the sides of the locomotives. There should be plugged outlets for incandescent lamps in each alternate space between pits.

Engine Pits.

Engine pits should be not less than 60 feet in length, with convex floor, with drainage toward the turntable. The walls and floors may be of concrete. Proper provision should be made for the support of the jacking timbers.

Floors.

The floor should be of permanent construction. It should be crowned between pits.

Form.

(a) The circular form is preferable.

(b) At points where not more than three or four locomotives are housed at one time, and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn locomotives, a rectangular house, either with through tracks or with switches at one end only, may be desirable.

(c) At shops where a transfer table is used, a rectangular engine house served by the transfer table may be desirable.

Heating.

(a) Heat should be concentrated at the pits.

---

[3] Adopted, Vol. 6, 1905, pp. 684-686, 690-696; Vol. 7, 1906, pp. 630, 638; Vol. 10, Part 2, 1909, pp. 1123, 1124, 1132-1136; Vol. 11, Part 2, 1910, pp. 1022, 1024-1026, 1049-1054; Vol. 16, 1915, pp. 740, 1149; Vol. 17, 1916, pp. 392, 912.

(b) The general temperature of the engine house should be kept between 50 and 60 degrees.

(c) The recommended method for heating is by hot air driven by fans through permanent ducts, which should be under the floor where practicable. The outlets should be fitted with dampers so that heat can be cut off while men are working in the pit. The fresh air supply should be taken from the exterior of the building and no recirculation allowed. It should be delivered to the pits under the engine portion of the locomotive. It should be heated as far as possible by exhaust steam, supplemented, as required, by live steam.

Hoists.

Hoists with differential blocks are generally used for handling heavy repair parts, and suitable provision should be provided for supporting them.

Length of House.

The length of stall along center line of track should be at least fifteen (15) feet greater than the over-all length of the locomotive, to provide a walkway behind the tender, a trucking space in front of the pilot and a certain distance in which to stop the locomotive or to move it to bring side rods or other parts into convenient positions.

Locomotive, Position of.

In a circular house the locomotive should stand normally with the tender toward the turntable.

Materials.

(a) The material used in construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(b) The additional security against interruption to traffic from fire warrants serious consideration of the use of a fireproof roof, and dividing the engine house into units of approximately 10 stalls by the use of division walls built of fireproof material.

(c) When the roof is of reinforced concrete the columns and roof-beams should be of the same material.

(d) Reinforced concrete should be used for the walls only where special conditions reduce its cost below that of brick or plain concrete, and should not be used for that portion of the wall directly in line of track where engine is liable to run into it.

Piping.

(a) The engine house should be equipped with piping for air, steam and water supply, and where desired, piping for a washout and refilling system should be installed. Where this system is installed, the blowoff lines should be led to a central reservoir; where it is not used, the blowoff lines should be led outside the house.

(b) The steam outlet should be located near the front end of the boiler. The blowoff pipe, the air, the washout and refilling water and the cold-water connections should be near the front end of the firebox. Connections need only be provided in alternate space between stalls.

Smoke Jacks.

The smoke jacks should be fixed. The bottom opening should be not less than forty-two (42) inches wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jack should be as low as the engines will allow, and it should be furnished with a drip trough. The slope upward should be gradual to the flue. The area of the cross-section of the flue should be not less than seven (7) square feet, and the jack should be made of non-combustible material. (This design of jack applies to all houses where regulations will permit. In some cities, where smoke abatement laws are in force, special design of jacks are necessary.)

When there is an engine house without turntable and no "Y" track or other means of turning provided, such engine house should preferably be equipped with smoke jacks at each end of each engine space.

Tools.

There should ordinarily be facilities provided for hand tools and for the location of a few machine tools, preferably electrically driven.

Tracks.

(a) Lead tracks to the turntable should line up with tracks of the engine house where possible.

(b) Tracks should be on a level grade and should be provided with stop blocks.

(c) Special fastenings of the track rails at the circle wall and on the turntable are desirable to prevent movement of the rails, to give good bearing and to lessen the damage from derailed wheels.

Turntable.

(a) The turntable should be long enough to balance the engine when the tender is empty.

(b) A deck turntable is preferable to a through table.

(c) At important terminals, turntables are most economically operated by mechanical means. Where few and light engines are turned, hand operation may be desirable.

Where electric power can be obtained at a reasonable cost, an electric tractor is the most efficient means for operating a turntable, the cost of power is cheaper, and it is superior in continuity of service and maintenance. The first cost is approximatey the same as an air motor of equal power and size.

Power wires are brought to the table by either the overhead or the underground method. Overhead device has the advantage of accessibility for inspection and repair. Special care must be taken to properly protect collector head from weather and gases and support collector rigidly (framework supporting same should be fastened to steel frame of table and not to ties, and must be securely braced) ; the wires should be large enough to keep them from breaking from sleet and should be supported to framework supporting collector. Any play at table multiplies at collector head. Wires should be brought to pole, close to curb of turntable, keeping lines as far distant from nearest wall of roundhouse as possible, to minimize the danger of destruction by fire.

When the underground system is properly installed, its advantages are that all exposed, non-current carrying parts are permanently grounded, including the circular-track rail (the only part of system to repair is collector head) ; non-interference from weather if turntable pit is properly drained.

The disadvantages are: the wire is not so easily repaired, and is much more difficult to originally install, as they must be properly protected from water, and cannot be successfully laid in a fill or on ground where settlement or shifting takes place. Where turntable pit cannot be well drained, it cannot be used with success. It has the advantage of protecting power to run table in case of fire to engine house, especially in one of a nearly complete circle.

Compressed air tractors are frequently used.

Ordinarily the power costs much more than electricity and is not so reliable. At points having no power plant the locomotive to be turned furnishes the compressed air; in this case an auxiliary supply should be maintained by providing small air tank secured to the turntable for operating it before or after the engine is placed.

(d) The deck on turntable should be wide enough to provide a walk on each side and be protected with hand rails.

Turntable Pit.

(a) The turntable pit should be well drained and preferably paved.

(b) The circle wall should be of concrete or brick, with proper supports and fastenings for rails on the coping.

(c) The circle rail should preferably bear directly on concrete base. The use of wood ties and tie plates supported by masonry is desirable under some conditions.

(d) Easy access to the parts of a turntable for the oiling of bearings, painting and inspection should be provided in the design of the turntable pit, unless ample provision is made in the turntable itself.

Window Lights.

(a) The disadvantages of skylights are so much greater than their advantages as to make them undesirable.

(b) Windows in the outer walls should be made as large as practicable with the largest glass or light area consistent with the requisite strength. In general, the lower sill should be not more than four feet from the floor, and only sufficient space left between pilasters and sides of window frames and girders and window heads to properly secure the window frames. Windows or transoms as large as practicable should be provided over all doors where locomotives enter. Window lights in doors are objectionable on account of difficulty of maintenance.

[4] FREIGHT HOUSES.

PRINCIPLES COVERING DESIGN OF INBOUND AND OUTBOUND.

General.

When the amount of freight handled is sufficient to justify it, separate houses for inbound and outbound freight are desirable. When these are provided the outbound house should be narrow, not more than 30 feet wide, and the inbound 40 to 60 feet wide, it being considered expensive operation where a house is in excess of 60 feet in width.

Where but a single house is needed, a width of from 30 to 40 feet is good practice.

In large cities it is frequently advisable to build the inbound houses several stories high, using the ground floor for handling freight and the balance of the structure for storage, to be leased to shippers. Most of the material stored will not be affected by heat or cold, but provision should be made for cold and warm storage where conditions warrant.

---

[4] Adopted, Vol. 15, 1914, pp. 710, 1099; Vol. 16, 1915, pp. 751, 1150; Vol. 18, 1917, pp. 815, 1529.

Cranes.

Where no gantry crane is provided in the freight yard, a stiff leg or pillar crane should be provided on the end of the extension platform.

Checkers' Stalls.

Stalls for checkers should be located at least one in each section. These should be approximately 4 feet 6 inches by 4 feet 6 inches, with a shelf along the back and drawers beneath. Sometimes they are left entirely open in front, and sometimes are closed up and heated, depending on local conditions. Some roads make their checkers' stalls portable, so as to allow them to be moved in case of a special congestion of freight at certain points, but this is not ordinarily considered necessary.

Doors.

Several kinds of doors are satisfactory—counterbalance lift (either folding or not), rolling shutters and horizontal sliding.

It is advantageous to have as much door opening on the team side as possible. With all types of doors except the last, all of the house can be opened except for the space occupied by posts.

With horizontal sliding doors not more than half of the space can be opened up at one time.

With no outside platform continuous doors should be used, so that an opening can be obtained at any point opposite a car door.

As all freight trucked into the house and cars must pass through the car door, the height of the freight-house door need be little greater than the car door. All door openings should be at least 8 feet high. On the team side a greater height might at times be convenient.

Downspouts.

It is not good practice to put downspouts inside the house, and in placing them outside they should be properly protected.

Economical Handling.

The economical handling of less-than-carload freight at terminals is a problem that is giving a great deal of concern. The cost of handling a ton of freight a mile by trains is known (approximately), but it is almost impossible to figure the cost per ton mile for trucking and handling of unclassified freight at the freight house. Freight house design should receive serious consideration.

Fenders.

On the team side of all freight houses a fender should be provided to protect the walls from the wagon wheels. A good type is one made up of an 8-inch by 10-inch timber set on brackets, with a spacer or separator to keep the timber approximately 2 inches away from the wall, so that dirt will filter through and not collect on the fender.

Fireproof Building.

Where the laws prohibit frame structures, or where the value of freight stored is considerable, and it is necessary to build freight houses of so-called fireproof materials, floors should be placed on a fill between foundation walls, and the exterior walls should be of masonry or steel frame covered with fireproof siding. Roof trusses, framing, etc., can be of wood covered with appropriate roofing, but to provide better protection fireproof construction should be used throughout.

Fire Protection.

General.

Where water pressure is available, standpipes and hose racks not more than 150 feet apart should be provided for fighting fire. By putting them on the fire and end walls they are thought to be more accessible and less liable to be blocked by freight than if located at other points, but by putting them about 44 feet from the end of each section fewer hose connections are necessary to cover the entire station. As there is no heat in the house, the valve controlling the water supply should be located below the frost line and controlled by a stem extending above the floor. The valve should be located in a pit, so as to be readily accessible for repair or renewal. It should be drained into the pit, and this in turn be connected to the sewer. A 2½-inch standpipe of wrought-iron should be run up to approximately 8 feet above the floor, and to this should be attached a hose rack, equipped with 50 feet of 2-inch linen hose. The Underwriters now recommend 1½-inch hose wherever it is to be handled by inexperienced men, but provision should be made on the water line for a 2½-inch outlet for city hose; care being taken that the threads on the outlet are the same as the city equipment.

Chemical Extinguishers.

Chemical extinguishers should be provided in addition to the hose and standpipes. As they are put out of service by freezing, some provision should be made for replacing them or keeping them warm. Tanks containing a solution of calcium chloride are used successfully.

Red Light.

In houses where electricity is available there should be over each hose rack a small red light to designate the location of the fire-fighting apparatus, this light to be kept burning at all times.

Watchman's Clock.

Where a watchman is needed, watchman's clock system, and stations located at various places throughout the freight houses, should be installed.

Fire Walls.

Areas Between Fire Walls.

Fire walls of brick or other non-combustible material should be located so as to conform to the requirements of the Underwriters. The strictest practice limits the area between fire walls to 5000 square feet. This especially applies to houses with no outside platform. In wide houses this locates the walls rather close together for economical operation. Fire walls should in no case be more than 200 feet apart.

Cover Each Side of Fire Wall in Non-Fireproof Buildings.

Where non-fireproof construction is used, the construction at the ends of the fire walls should be fireproof for a distance of at least five feet on either side of the fire wall. This is especially desired where there are overhanging roofs.

Doors in Fire Walls.

Doors in fire walls should be as limited in number as possible. No one-door opening should exceed in area 80 square feet, and all openings should be equipped with automatic fire doors.

Floors.

Floor Above Street Grade.

On the street side the floor of the inbound house should be from 3 feet to 4 feet above the street grade, depending on the type of trucks in use. At the outbound house the height should not exceed 3 feet.

Slope of Floor.

To assist trucking the floor of the inbound house should be sloped toward the street approximately 1 inch in 8 feet, this being for the house proper. An outside platform on the track side should slope approximately 1 inch toward the tracks for draining.

For the outbound house the floor should slope from the street to the edge of the platform alongside of the car not more than 1 inch in 8 feet.

Frame Building.

General.

In outlying districts, where fire hazard is not great, business not large and the building laws will permit, frame freight houses having wood floors on joists, studding covered with wood sheathing or metal siding, and wood rafters and sheathing covered with appropriate roofing, are fairly satisfactory and cost less than any other type. Floor for this type should ordinarily be designed to carry 250 lb. per square foot.

Floor Ventilation.

With such construction there should be ventilation beneath the floor. Access to the space under the house should be prevented to avoid the accumulation of rubbish and increased fire hazard.

Filled Floor.

Even where a frame house is to be used it is better practice to use a fill between masonry foundation walls, eliminating some fire hazard and decreasing maintenance charges.

Heating Plant.

The basement should house the heating plant, with room for a season's supply of coal.

Lighting.

Artificial Light.

Artificial light is needed for operation at night and during the late afternoon in the winter, and wherever possible electricity should be used, with wires run according to the specifications of the National Board of Underwriters. One or more lines of lights should be run the full length inside the house, and one line over outside platforms.

Another circuit should be run along the face of the platform wall parallel to the track, with outlet boxes not over 44 feet on centers, with socket arrangement for push plug for use in attaching an extension cord to hang inside the car to provide light for loading on dark days and at night.

The type of lights will depend somewhat on the height of the ceiling. All lights should be stationary and operated in circuits from conveniently located panel-boards. The circuits should be carefully planned, so as to allow maximum economy in use of lights.

Natural Light.

Natural light should preferably be provided in the side walls above the doors. Skylights in the roof are expensive to maintain and ineffective, as is also glass in canopies, or on any plane approaching the horizontal.

Offices.

In large houses a separate office should be provided for the foreman. If this can be an elevated structure it will save floor space.

In large houses the general office for the clerks and the private office for the agent should be provided by a second story over the inbound house, and in the second story should also be a space for file, records and stationery cases, toilets and locker facilities for clerks. This all should, as far as possible, be in view from the desks of the agent or chief clerk. The cashier and his clerk should ordinarily be located on the first floor.

Where possible it is preferable to have the clerks' and agents' offices, the toilet rooms, etc., for the freight handlers and draymen, the room for "over, short and damaged freight," and the cooperage room for repairing broken packages, etc., all in one section. These can be located in the basement providing there is room.

In the larger terminals provision may be wanted to care for perishable freight, and when it is provided it should also be located in this section.

O., S. and D. Room.

In inbound houses a room should be provided to house "over, short and damaged freight," this to be enclosed so that it can be kept locked.

Panel Length.

Where an outside platform is provided, a door in each panel is sufficient. Considering the average length of cars and economy in framing, 22 feet is a good panel length.

Platforms.

General.

A platform 8 to 10 feet wide along the track side of the house avoids the necessity of considering the location of doors in spotting cars on the track next to the house, and also eliminates the necessity of keeping an aisleway inside the house on the track side. It should be at least 8 feet wide to give sufficient room for hand trucks to pass, and where electric trucks are used the platform should be at least 12 feet wide.

Freight House Without Outside Platforms.

Freight houses without outside platforms may be desirable in some localities, especially in northern climates, where there is considerable snow and sleet, as these houses can be entirely closed, except for that part of the house where the freight is being received or loaded. At some points, where ample track room is not available, the elimination of the outside platform possibly gives better results.

With this type it is necessary to leave more trucking space inside the house, longitudinally the full length of the building. With the house congested with freight it is difficult to keep the aisleways from being crowded up, making it almost impossible to get through with a truck that is loaded with large packages. This causes delay and confusion.

Ramped Extensions for Bulky Material.

For loading and unloading agricultural implements and other large, bulky packages, platforms should be built, usually as extensions to the inbound and outbound houses, with ramps on the ends of the platforms. The extension platforms should be at least 8 feet wide, and if possible 16 feet wide, especially if covered. A stub-end track butting against a platform with a ramp is valuable.

Transfer Platform.

Where both outbound and inbound houses are arranged in the same layout a transfer platform is usually included. One of the best designs for covering these platforms is a butterfly shed, with the posts located in the center of the platform. Where this design is used the platform should not be less than 12 feet wide, to provide room for trucks between the posts and the cars.

Roofs.

Roof Over Cars.

Where State laws permit, protection over the cars is often used. This should be at least 17 feet above the top of rail, and should preferably extend to within 18 inches of the middle of the car. This will allow walking on the top of cars.

Roof Over Platform.

The platform should be protected by an overhanging roof, not greater than the width of the platform and at least 10 feet above the platform level.

Roof Over Trucks.

There should also be an overhanging roof or other protection on the team side to protect goods while being unloaded, the overhang to be at least 4 feet and preferably more, 12 feet at least being needed to give protection from a driving rain.

On account of merchandise being piled high on trucks, it is desirable to have at least 14 feet above the level of the driveway.

Posts.

It is advantageous to have the floor entirely free from posts, but in houses approaching 50 feet in width the saving made by using posts becomes considerable and great enough to offset the advantages due to their omission.

Repair Room.

In large layouts, particularly where there is considerable transfer business, a room should be provided for repairing broken packages, such as crates, boxes, barrels, etc.

Scales.

General.

The weighing of package freight at freight houses is very important from a revenue standpoint, and the railroads are installing a greater number of scales, and giving serious consideration to the weighing of all package freight, except possibly standard packages of known weight. There are some points where practically all the freight handled is of standard package freight, and at such houses very few scales are needed.

There are three classes of freight terminals, the largest being where both inbound and outbound houses are arranged in the same layout. At such points the following arrangement of scales is recommended:

Combination Inbound and Outbound Houses.

In layouts where one house handles both inbound and outbound freight, and where the business is heavy and diversified, the scales should be located preferably at every third door opening, or a maximum of 75-ft. centers. Where this number of scales are used they should be ample to take care of outbound weighing. Scales should be located on the driveway side of the house.

Combination Freight and Baggage Rooms.

At small outlying stations, where there is a combination baggage and freight room, fixed scale with platform level with the freight room floor, located preferably at one side of the door nearest the driveway side, is recommended, as at this point it will be less liable to damage from trunks or large packages.

Separate Outbound and Inbound Houses in Same Layout.

In outbound houses it is desirable to have a scale at every second door opening, or a maximum of 75-ft. centers. These to be located approximately 6 to 8 feet from the receiving side of the house.

In inbound houses it is desirable to have scales placed 100-ft. centers, as the maximum, and located on the receiving side.

Capacity.

Scales for houses handling freight only should have a minimum capacity of four (4) tons. Higher capacity scales cost very little more and are economical from an operating and maintenance standpoint, as they will stand up better under the abuse they are usually subjected to.

At combination freight and baggage rooms fixed scale level with the freight house floor, with a minimum capacity of two (2) tons is recommended.

Location.

The ideal location for scales is to so place them that freight can be weighed as received and trucked to cars without re-handling.

Platforms.

In large houses scale platforms should be as small as practicable to accommodate the trucks used, and usually not over 6 ft. by 8ft., except at certain localities, where one or two large scales are necessary to handle freight that is especially bulky.

Type of Scale.

Where large volume of freight is handled during short periods, dial attachments to scales are recommended, as the additional cost and maintenance is justified by the increased amount of freight that can be handled.

At terminal stations, where scales can be given proper attention and where the volume of business will justify, dial scales are preferred for weighing mail, baggage and express.

Tracks.

Distance to Center Line of Track.

The distance from the center of the nearest track to the face of the platform or freight house should be not less than 5 feet 9 inches, where tracks are on tangents. The alternative of spacing tracks at least 7 feet from platforms is usually expensive at important terminals.

Distance Platform to Top of Rail.

The top of rail should be not more than 4 feet below the floor or platform level at the track edge, where refrigerator cars are not to be handled in any quantity. With occasional refrigerator cars the doors can be opened before the cars are set.

Where refrigerator cars are to be handled regularly, the height should not be more than 3 feet 8 inches, this conforming to the recommendation of the M. C. B. Association. (See M. C. B. Proceedings for 1911, Vol. 45, p. 728.) Many roads are building cars that are lower than the maximum figures given above, and each road, in deciding the height of platform above the top of rail, should take into consideration the sizes of cars that predominate on its line.

[5] LOCOMOTIVE COALING STATIONS.

(1) To properly compare the relative economy of locomotive coaling stations, the cost per ton of handling coal should include charges for interest and depreciation on the investment, charges for maintenance and operation and a charge for the cost of such actual storage as is required in the daily operation of the coaling station itself. The additional seasonal storage required in certain parts of the country to be considered as a separate proposition. Most of these charges are included in accounts prescribed by the Interstate Commerce Commission in the "Issue of 1914," effective July 1, 1914. The classification of "Investment in Road and Equipment" shows an account, "Fuel Stations," covering all the investment except the cost of required tracks and right-of-way. The classification of "Operating Expenses" prescribes an account, "Fuel Stations," covering essentially repairs to coaling stations; an account, "Fuel Station Depreciation," permitting charges for estimated depreciation, and accounts "Fuel for Yard Locomotives" and "Fuel for Train Locomotives," which include in the cost of fuel all the costs of operation of the plant itself. These prescribed accounts do not include the cost of switching cars onto trestle or coaling tracks, nor the cost of using cars for storage purposes, all of which should be included in figuring the cost per ton of handling coal.

(2) Provision should be made for fire protection, the avoidance of damage to the coal and its delivery in the best possible condition.

(3) The use of self-clearing cars should be made possible, and ordinarily it should also be possible to shovel from flat-bottomed cars.

(4) Storage for emergency purposes and fireproof construction are, in general, to be recommended. In some cases duplicate machinery is desirable.

Where coal is stored in summer for use in locomotive stations in winter, and where the amount stored is less than 75,000 tons, no special mechanical device is recommended, it being more economical to store it by unloading cars by hand or crane and reclaiming it by the use of tools that can be put to other use when not handling coal, such as locomotive crane, ditcher or steam shovel.

(5) It is not possible to give absolute limits between which different types of coaling arrangements are recommended for use. Each installation must be considered as an individual problem. Before the selection

---

[5] Adopted, Vol. 8, 1907, pp. 268, 286; Vol. 9, 1908, pp. 163-166, 173, 183-200; Vol. 11, Part 2, 1910, pp. 1027, 1054; Vol. 16, 1915, pp. 743, 1149; Vol. 20, 1919, pp. 209, 869.

of a type of coaling station can be based upon the least cost per ton of handling coal, consideration must be given to the extent to which investments in permanent structures and the adoption of fixed track arrangements are warranted, and consideration should be given to price of materials, cost and character of labor, possible track arrangements, amount of coal desired, fire protection, power and attendance and shifting service available and the cost of maintenance.

(a) Where the quantity of coal handled is small, particularly at terminal points where locomotives lie over night, it is recommended that the locomotives be coaled either directly from cars or by handling from cars to an elevated platform provided with a jib crane and one-ton buckets, and from these buckets to the locomotive.

(b) A locomotive crane with suitable buckets is desirable at terminals under certain conditions, particularly where other work can be economically performed by the locomotive crane.

(c) For terminals larger than those previously described, the type of coaling station which should be selected as most desirable is dependent entirely upon local conditions. Where it is required that coal be delivered to not more than two tracks, and where the necessary ground space is available, a coaling station of the trestle or gravity type, with approximately five (5) per cent. incline approach, where coal in cars is placed on top of the trestle by locomotives, the coal being stored in bins from where it is placed on the locomotives by gravity, is recommended. Where it is required to deliver coal to more than two tracks, or where the ground space for a trestle type is not available, a mechanical type is recommended.

[6] OIL HOUSES.

(1) Oil houses at terminals should be separated from other buildings.

(2) Oil houses should be fireproof and the storage in large houses should preferably be either underground or in the basement.

(3) Oils that are stored in sufficient quantities should be delivered to the tanks in the house direct from tank cars. For oils that are stored only in small quantities, provision should be made for delivery to storage tanks from barrels by pipes through the floor.

---

[6] Adopted, Vol. 10, 1909, pp. 1127, 1128, 1136-1140; Vol. 11, Part 2, 1910, pp. 1027, 1037, 1054; Vol. 16, 1915, pp. 745, 1149.

(4) The delivery system from the storage tanks to the faucets should be such that the oil can be delivered quickly and measured automatically. The delivery should also be such that there will be a minimum of dripping at the faucet and that the dripping may drain back to the storage tanks.

(5) Openings for ventilation should be provided above the level of the top of the tanks.

(6) Lighting, when required, should be by electricity and heating by steam.

(7) For fire protection purposes a live-steam line should be run to the oil storage space, controlled by a valve outside the house.

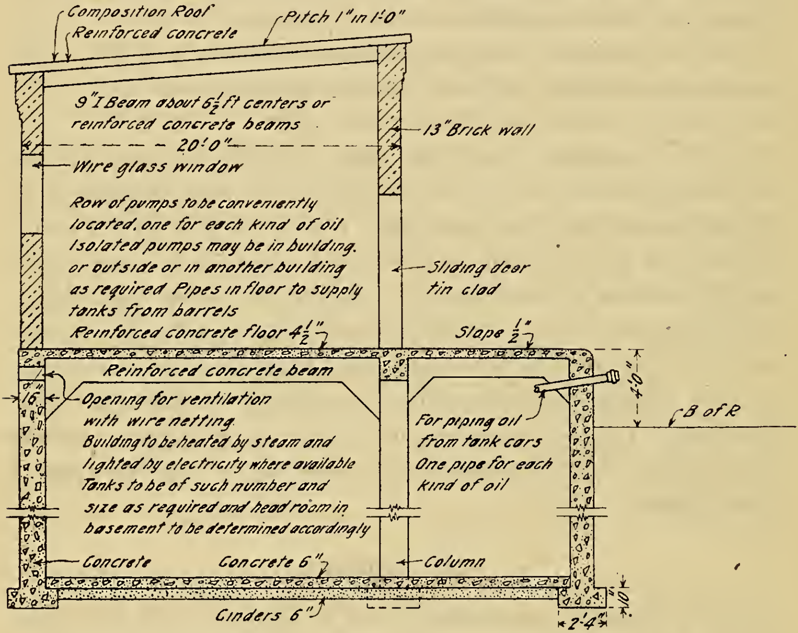

Composition Roof
Reinforced concrete
Pitch 1" in 1'-0"
9" I Beam about 6½ ft centers or reinforced concrete beams
20'-0"
13" Brick wall
Wire glass window
Row of pumps to be conveniently located, one for each kind of oil. Isolated pumps may be in building, or outside or in another building as required. Pipes in floor to supply tanks from barrels
Reinforced concrete floor 4½"
Sliding door tin clad
Slope ½"
Reinforced concrete beam
16"
Opening for ventilation with wire netting
Building to be heated by steam and lighted by electricity where available
Tanks to be of such number and size as required and head room in basement to be determined accordingly
For piping oil from tank cars
One pipe for each kind of oil
4'-0"
B of R
Concrete
Concrete 6"
Column
Cinders 6"
2'-4½"
10"

FIG. 2. CROSS-SECTION OF TYPICAL OIL HOUSE, 20 BY 40 FEET.

[7] PASSENGER STATIONS.

Passenger Stations with One General Waiting Room.

The use of one general waiting room for a passenger station (without reference to separate waiting rooms for colored people) is recommended as good practice for the following reasons:

---

[7] Adopted, Vol. 6, 1905, pp. 682-684, 690; Vol. 11, Part 2, 1910, pp. 1022, 1023, 1049; Vol. 16, 1915, pp. 739, 780, 1149, 1151; Vol. 19, 1918, pp. 265, 1091; Vol. 20, 1919, pp. 211, 213, 870.

(1) It permits the general waiting room to be properly proportioned.

(2) It permits proper development of a retiring room for women, with private entrance to the lavatory.

(3) It readily admits of the other rooms being properly proportioned.

(4) It permits ease of access from the agent's office to the trains, to the baggage room and to the waiting room.

(5) It permits the ticket office to be of proper size and location for general office purposes.

(6) It admits of the station being contracted in size without detriment to facilities.

(7) It offers economy in heating.

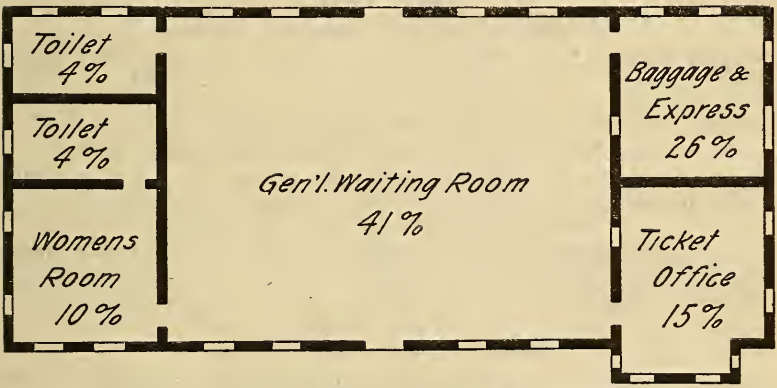


FIG. 1. DIVISION OF FLOOR AREA RECOMMENDED FOR PASSENGER STATIONS WITH ONE GENERAL WAITING ROOM.

Heating.

Method of, for Medium-Sized Stations.

Stations with one or two waiting rooms, and an office, can be heated satisfactorily and economically by the use of stoves, especially where it is not necessary to maintain an even temperature throughout the entire day. The danger of fire from the use of stoves should be guarded against as much as possible.

Where two or more waiting rooms separated by an office are to be heated, a single central heating plant, preferably in the basement, is recommended as being the most economical and satisfactory. For such a heating plant a hot water, steam or hot air furnace may be used. The hot air furnace constitutes a greater fire risk than either the steam or hot water heater. An even temperature is more easily maintained by hot water than by steam, but a station is more quickly heated with a steam system than with a hot water system. The pipes and radiators of a hot water system must be kept above a freezing temperature.

Lighting, Electric.

Electricity is the safest, most satisfactory and desirable method of lighting, and should be installed in all stations where reliable current is available at reasonable cost.

It is recommended that lighting be provided according to the two schedules following. The table gives general figures showing the approximate amount of light required at various locations in and around passenger stations:

First Class

Important City and Suburban Stations

Waiting Room	Direct	3 to 3.5	foot candles
Ticket Office	Direct	3.5 to 4.5	" "
Ticket Windows	Direct, 1 drop	4 to 4.5	" "
Baggage Room	General Illumination	1 to 2	" "

With Local Drop Over Desk and Window.

News Stand	Direct Illumination	5	foot candles
Toilet Rooms	Direct General Illumination	1.5 to 2	" "

With One Drop Over Each Two Stalls.

Cover Sheds and Main Platforms	Direct	1.5	foot candles
Outlying Platforms	Direct	1	" "
Station Approaches	Direct	1 to 1.5	" "

Second Class

Unimportant Country Stations

Waiting Room	Direct General Illumination	3	foot candles
Ticket Office	Direct General Illumination	3.5	" "
Ticket Window	One 25 Watt Lamp	3.5	" "
Baggage Room	Direct Illumination (1 or more drop)		
Toilet Room	Direct (generally 1 drop is sufficient)		
Platform adjacent to Station	Direct	1 to 1.5	foot candles
Outlying Platforms	Direct	25 to 5	" "

The center of distribution of the lights for the station and surroundings should be located conveniently to the office of the official responsible for the economical use of same.

Platforms (High Platforms at Passenger Stations).

It is recommended that high platforms be provided only in connection with tracks devoted exclusively to passenger traffic.

Sanitary Provisions for Stations.

In all stations different planes should be connected by curves; all heads and angles that may collect dirt and protect disease germs should be avoided; and sufficient artificial light should be provided, as dark places are the ones that collect dirt and filth.

Shelter Sheds.

In that part of the country where heavy snow occurs Umbrella type of shed is preferable though somewhat more expensive in first cost.

In that part of the country where heavy snows are not a factor, the Butterfly type of shed is preferable.

Stairways.

General.

These recommendations include the main requirements of building codes of a number of representative large cities, but should be used with due regard to local city and state regulations. Provisions as to strength of construction and fireproof features are not included.

Avoid steps and stairways where inclines and ramps can be satisfactorily used instead. Avoid any combination of sloping surfaces and steps.

Consider both the general design and details of stairway construction with a view of handling crowds of people with the individuals moving in parallel lines with ease and with safety, against slipping and falling, keeping such movement free from interference by other lines of travel.

In connection with the construction of new passenger stations and the maintenance and alteration of old stations, special study and consideration should be given to provisions for the safety of pedestrians in an effort to remove, as far as possible, all risks of personal injury, particularly from slipping, stumbling and falling. The actual risks and their relative economic importance are revealed by experience of railroads handling rush crowds, the statistics of insurance and compensation bureaus, and are also reflected by state and city building codes, relative to construction of factories, schools, auditoriums, etc.

Personal injury in and about passenger stations results either from colliding or slipping and stumbling.

Where crowds are handled, injury from colliding of persons with trains or trucks should be guarded against by arrangements to prevent passengers crossing tracks, to eliminate or reduce to a minimum the trucking of baggage, mail, and express on main passenger platforms, and to guard people waiting on platforms at way stations, by the use of dead lines or station fences.

Colliding of persons with hand baggage and each other should be prevented or largely avoided by proper general arrangements of depots, particularly in the matter of location and proportions of passageways and stairways, with the primary object of separating different classes, or lines, of traffic as much as may be practicable, and of maintaining any certain line of traffic free from interference and points of congestion. Particular attention should be given to the location of ticket offices, information bureaus, check rooms, entrances to minor waiting rooms, and similar conveniences, and a study made of possible interference with main lines of rush travel. Concourses should be provided with as many main exits as practicable to prevent unnecessary travel through main waiting room—union depots recently built, showing that often 70 per cent. of the traffic can be thus handled.

Personal injury from slipping, stumbling and falling should be guarded against by choice of finish and wearing surfaces for floors and platforms, by avoidance of many details in common use which induce stumbling and slipping, by proper construction of ramps and stairways, including the use of safety treads on all main stairways, and by proper standards of maintenance, both as to condition of use and time of renewal or repair.

The construction of stairways in passenger stations should conform as to safety features to the recommendations given below.

No plans for extensive alteration of existing passenger depots, or general layouts for new stations, should be approved without a critical examination or study being made of the traffic movement in rush hours, and no details of construction should be used affecting stairways and surfaces on which passengers walk without careful consideration be given with a view to avoid or reduce as much as may be possible the risk of personal injury to passengers in and about stations.

Drainage.

Obtain necessary drainage at the ends of the treads, and not by sloping the surface in line of travel.

Location, General.

Place important stairways conspicuously in the main line of travel, keeping such travel in straight lines where possible. Arrange so that crowds at the head and foot of stairways can naturally assemble and disperse, with a minimum amount of confusion and cross-currents of walking. To this end, provide at the top and bottom of stairways, where possible, corridors or vestibules, using the same width as for the stairway. Such corridors should open directly into the room served without any funnel-shaped entrances, and with plenty of room for quick distribution.

Locate minor stairways away from regular lines of travel, and avoid combinations of service or minor stairways, with main stairway.

Consider possible lighting arrangements, particularly from natural light, avoiding locations where stairways will be poorly lighted in cloudy weather or where they will appear dark to a person entering them from bright sunlight.

Lighting.

In making lighting arrangements, consider that many people with poor eyes cannot, at best, see very clearly in descending stairways, particularly when the appearance of treads is uniform throughout. Provide ample natural and artificial light, avoiding direct light and shadows, and making certain that lights from adjacent rooms do not shine directly into the eyes of people using stairways.

Maintenance.

In the choice of materials and arrangements, consider the maintenance conditions that will exist in daily use, particularly those in wet and stormy weather just before stairways are cleaned, and also give consideration to that poorest condition of safety treads and other parts which will exist just before renewal is required and made.

Pitch and Landings.

The pitch of stairways, i. e., the inclination as determined by the dimensions of treads and risers, and the frequency and proportion of landings, should be such that stairways may be ascended with ease, and as nearly as may be with a free natural walking step. The continuous upward lifting of the body, for anyone not accustomed to such exercise, and particularly for fleshy people, those with weak hearts, or anyone in poor health, is a great exertion. Landings break the continuity of this exertion, and offer a needed resting place for the weak. To fix pitch and landings properly, the following should be approximately observed:

Provide treads not over 13 in. nor less than 11 in. in width, and risers not over 7 in. nor less than 6 in. in height; and make the sum of two risers and one tread be between 25 in. and 26 in. The width of treads should be taken as the horizontal distance face to face of risers.

Where stairways require more than 16 risers, provide intermediate landings, keeping the length of single flights as near to 10 or 12 risers as may be possible. Use no steps with less than three risers.

Where feasible, provide the same height of risers and width of treads for all stairways used by the traveling public in any one building. Always make risers and stringers of closed construction.

Make the width of landings in the direction of travel not less than four feet.

Avoid, if possible, all minor entrances on landings or at the top or bottom of main stairways. If this cannot be done, provide suitable length of landings, so that doors can be opened and used freely by any minor class of traffic without, in anywise, causing interference with travel at the main stairway.

Railings.

Provide hand rails on both sides of all stairways and center rails on stairways eight feet wide, and additional rails to keep the distance between adjacent hand rails not less than 3 ft. 0 in. nor more than 6 ft. 0 in. Where intermediate hand rails are used, a double hand rail is recommended. Place center line of hand rails at least 5 in. from face of sidewalls, or 8 in. center to center for intermediate hand rails. Make section of hand rail rigid to give uninterrupted travel for a secure grip. Provide a hand rail without sharp drops or raises, and extend it beyond the last riser, and turn it downward, so that it offers no entanglement for clothes or baggage. Curve hand rails at all bends on landings. Provide such balustrades and hand rails as will prevent small children from falling or getting through them. In this connection, consider the use of curb to divide stairs under the center hand rails. Place top of hand rail 34 in. above tread, measured on line of face of riser. On the open side of stairway, provide barriers at least 42 in. high, to guard against accidental falls of persons over balustrade. At intermediate hand rails, provide newels not less than 6 ft. high, and secure the rails to them without encroaching on hand clearance. Provide newels which will not present sharp edges and corners.

Signs.

Place no signs, mirrors, or other objects of interest where they will attract the attention of persons using stairways, except such signs as are necessary to direct travel.

Stairways, Outside.

Where feasible, enclose, or roof over, all outside stairways not only to keep off sleet and snow, but also to prevent a slippery condition, due to rain and mud. Do not provide open risers. In choice of safety treads for outside stairways, consider means which will have to be used during winter weather to maintain surface of steps in good condition.

Treads.

Where used, nosings on treads should be limited to a projection of one inch.

Provide approved safety treads on all main stairways, using a renewable type securely fastened. Make length of safety tread 4 to 6 in. shorter than that of the stair tread, and use a width of safety tread of from 5 in. to 8 in. Place the surface of the safety tread flush with surface of the balance of the stair tread. Consider means, such as color schemes, which used in connection with safety treads, will clearly indicate the location of the steps, particularly the outer edge or nosing.

The use of wide safety treads, particularly those covering the entire width of the step, are of questionable necessity and value, as they present a uniform appearance for the entire flight of steps, and make it difficult for people to clearly see where they are stepping.

Type.

For main stairways, use a straight run of steps and landings wherever architecturally possible. Where turns cannot be avoided, provide landings and, if possible, restrict the turn to ninety degrees.

Width.

Proportion the width according to the character of traffic handled, the extent to which hand baggage will be carried, and the maximum stairway capacity desired during rush hours. Be guided by experience with local requirements rather than by thumb rules, bearing in mind that main stairways should be maintained wide enough so as not to check the movement of crowds, and that the width of minor stairways should often be determined by the rate at which people may continue to move away from them. (See text of report for certain data obtained in connection with construction of Hudson Terminal Building, New York).

Bevel, or round, landings to maintain a constant width, and keep people moving in concentric, or parallel lines.

Where two stairways unite at a landing and form a single stairway, make the width of the latter equal to the combined widths of the other two.

For minor and service stairways, use no width less than 3 ft. 0 in. between hand rails.

[8] REST HOUSES.

Purpose.

Rest houses are built to furnish hotel accommodations for trainmen held at terminals away from home. The need of these houses is increasing with the construction of large terminals away from the centers of the towns. With them the men can be given clean and satisfactory accommodations, are kept out of temptation, are in better condition for their work, and are close at hand when wanted. The success of the house is dependent very largely upon the manager. With a man having the requisite ability and enthusiasm the house and its associations can be made attractive and to have a valuable influence.

Railroad Y. M. C. A.

The Railroad Y. M. C. A., which operates many of the houses, is able to help find good managers and through its experience to assist in getting good results. Its methods, which put part of the management upon the men, usually works successfully. A house built for their use is not different from what will give good results if run directly by the railroad.

Attractiveness.

Especial effort should be made to have it attractive and give a pleasing first impression.

Bedrooms.

No provision is ordinarily made for using the bedrooms except for sleeping purposes.

---

[8] Adopted, Vol. 16, 1915, pp. 766, 1151.

Beds.

Ventilation for the sleeping rooms should be provided by transoms over the doors; as a substitute an opening of approximately two inches at the top and bottom of the doors can be used.

Ventilation over the ceiling of the top floor is very desirable to avoid excessive heat in the sleeping rooms in hot weather.

Double-deck beds are being used, and while they are economical in space, they are not as desirable as single beds. Under average conditions beds for about 75 per cent. of the number to be provided for daily are necessary.

Outside Windows.

Every sleeping room should be provided with an outside window.

Partitions Above Floor and Below Ceiling.

Partitions are sometimes stopped about a foot from the floor and a foot or two from the ceiling. This puts control of ventilation and heating of the sleeping rooms in charge of the manager, but gives a house which is hard to keep clean, and the half-open rooms cannot be fumigated or swept without disturbing occupants of adjacent rooms. Noisy men in one room may disturb everybody else on the same floor. With full partitions, occupants of rooms are able to adjust heat and ventilation to suit themselves. Some houses with open partitions have a screen between the partition and the ceiling and floor to keep intruders out.

Sleeping rooms should be cut off from the rest of the house so that odors from the dining room and kitchen, and noise and smoke from the lounging rooms and office are kept out. Doors at the head or foot of the stairways are ordinarily necessary. This also allows a more economical use of heat.

Small sleeping rooms are preferable to dormitories, and for economy of space rooms 8 feet by 10 feet are recommended. The size will accommodate two beds. Chairs and coat hooks should be provided.

If regular boarders are to be provided for, the room should be furnished with a table and locker.

Check Room and Safe.

There should be a check room and a safe for valuables.

Design, Requirements of.

The design of the rest house must vary with the character of the traffic in which the men to be accommodated are engaged. At some points the taking care of regular boarders, such as shopmen, switchmen and telegraph operators, and the average length of lay-over of the roadmen must be considered.

Entrance.

There should be but one public entrance. The entrance lobby should be a room large enough to serve as a center for the activities of the building, and to contain an office for the manager.

Environs.

Provision should be made for pleasing exterior surroundings—walks, shrubs and perhaps also provision for croquet and quoits.

Expansion, Provision for.

In planning the house it is always well to make provision for expansion. A very large majority of the houses already built have had to be increased in size or are badly in need of it.

Dining Room.

Counter.

The counter top, as a rule, is 3 feet 1 inch above the floor, but some counters are built approximately 30 inches above the floor—the same as a table—and in counters of this height it allows the men to sit and place their feet on the floor instead of having to use a foot-rail.

The top should have an impervious surface without cracks and openings where dirt and vermin can lodge, and the whole counter should be so constructed that the top will project approximately 12 inches, so that a man can sit close to the counter without striking his knees.

It is usually better to have the counter U-shaped (with the waiters in the center), rather than around the sides of the room, with the attendants working between it and the wall. This allows quicker service. For the ordinary house the counter should be so located that ready access can be had for the attendant at the counter to the desk at the office. At the smaller houses, particularly, this will allow for cutting down of the force to one man at night.

A space of at least 6 inches should be left between the floor and bottom of the counter to admit of thorough cleaning.

For the house serving mostly freight trainmen, tables are not necessary in the dining rooms, and a counter gives in many ways more satisfactory results. It is easier and cheaper to serve, and less space is required. The roadmen ordinarily prefer the counter.

At the lunch-counter metal stools with revolving wood tops and a large flaring base that can be securely fastened to the floor are recommended. They should be spaced not less than 27 inches on centers.

Tables for Regulars and Passenger Men.

Where there is a considerable proportion of regular boarders or passenger men there should be tables in addition to the counter.

Tablecloths are very hard to keep in an attractive condition, and sometimes the tables are used without cloths. However, some of the Y.M.C.A. men think that a table set with a cloth is worth the cost, in that it has a restraining home influence.

Metal chairs, with wood seats, are recommended at tables.

Fire Protection and Safety Appliances.

Fire extinguishers, fire escapes, fire gongs and all the best appliances for fire prevention should be used. A fireproof building is to be strongly recommended. In frame houses the kitchen should always be built with a view to fire protection.

Fireproof Cost.

A fireproof structure will cost approximately 50 per cent. more than a wooden building.

Heat.

It is good practice to locate the house so that heat can be had from a shop power plant. With a vacuum heating system steam can be economically piped for at least half a mile under favorable conditions.

Hospital, Emergency.

Consideration should be given to the provision of a small emergency hospital.

Kitchen.

Planning of the kitchen is a very important matter.

Cool Room.

In the basement a cool room is desirable so that large quantities of vegetables can be bought at one time.

Coal Storage.

In the basement there should be provided ample room for the storage of coal for ranges and for the heating plant, where impossible to locate the plant outside of the main building. Frequently a bin large enough to take a carload is desirable. A small metal coal bin should be provided near the kitchen range.

Fan.

In a large kitchen an exhaust fan is desirable. This will pull from the rest of the house and will keep cooking odors out of the building.

Ice Box.

Too often sufficient room is not allowed for the ice box. There should be no skimping in providing ample refrigeration, as without it there is a chance for considerable loss. The location of the ice box is important.

It should have an outside opening for the ice. Adequate drainage should be provided.

Light and Ventilation.

It should be light and have good ventilation.

Pastry Room.

With a separate pastry room in the larger houses the work can then be done without interference with the regular work and with more cleanliness. In a small house such an arrangement would require more help, and is not ordinarily desired.

Plan.

The kitchen should be so planned that there will be a minimum of interference between the waiters and the cooks and dishwashers.

Range Hoods.

There should, in any event, be hoods over the range to carry off odors, and the chimney should have a flue for this purpose.

Separate Waiters from Kitchen Help.

The waiters can often be kept separate from the kitchen help by the tables. The food should ordinarily move directly from the storeroom and ice box to the ranges and serving and steam tables.

Shelf Room.

Ample shelf room for dishes and stores must be planned for. While for cleanliness it seems desirable to keep the kitchen as free from shelves and cupboards as possible, it is economical to have supplies and utensils accessible; but a separate storeroom makes it harder to supervise the help, giving a convenient place for loafing.

Steam Tables.

Steam tables should be provided where practicable, even in the small houses. They save fuel, are cleanly and for many articles give better results than a range.

Storeroom, No Outside Entrance to.

If a storeroom is provided, it should not have an outside entrance, as it is practically impossible to keep it locked, and this encourages thieving.

Lecture Room.

A room which can be used for lectures and assemblies of various kinds is sometimes quite desirable, especially where it is possible to make some effort for entertainment of the men. Such rooms are also at times valuable for the railroad officers in handling investigations and instruction classes, the rest house being often a desirable place for such work. However, it has been found by experience at some houses that such rooms were not used often enough to warrant their cost and that, where necessary, a part of one of the amusement rooms could temporarily be shut off.

Lighting.

Electricity should be used for lighting even if a separate plant for providing it is necessary. It is cleaner and the danger from fire is much less when it is used.

Linen Closets.

Linen closets should also be provided on the sleeping room floors, and ample room for storage in connection with the office is also desirable. Dark spaces not available for sleeping rooms can be thus utilized.

Lockers.

Lockers allowing the storage of articles to be left in the house between trips are also desirable. To them the men should have access, and they can usually be put in the basement.

Office.

The office should have room for a desk, where necessary clerical work can be done. It should be located so that the attendant can have the fullest possible view of the reading and amusement rooms and of the dining room.

A private office for the manager is sometimes thought necessary, but in smaller houses this can be avoided.

Porch.

A big porch adds much to the comfort of the house; as a general proposition it should not be located on the street side, as some men are likely to make unbecoming remarks to passersby.

A foot rest of 3-inch gas pipe, about ten inches out from the porch rail and about two feet from the floor, supported by brackets, makes a good foot rest and saves wear on the paint.

Quarters for Manager and Family.

In many localities suitable quarters for the manager and his family are necessary in the building.

Recreation Rooms.

The amount of room for amusement, reading, etc., is to be determined by the character of the service for which provision is made. It is important that no skimping be done in this respect if full value is to be had from the house.

It seems to be the generally accepted opinion that open rooms connected together with wide openings are better than reading and amusement rooms separate from the lobby. The men can be kept under the eye of the manager easily, and the number who want quiet is not ordinarily great, although in a big house provision for them may be desirable. Provision for bowling alleys, pool tables and other games in addition to the reading room are desirable, bowling alleys to be located where the noise will be least objectionable.

Register and Sales Counter.

There should be a counter where a register can be kept, and also space provided for the sale of necessary articles.

Sanitary Floors.

If a wooden structure is necessary, some sanitary floors can be provided, but with a brick or concrete building their use can be more extended and other improvements, such as a sanitary base, can be more easily provided.

Sanitation Made Easy.

No reasonable expense should be spared in making it easier to keep the house sanitary. The houses ordinarily get shabby very easily and materials and colors should be selected which will wear well. Where plastered walls are used in the game rooms, lobbies and halls, it is desirable to have the walls, for a height of four feet, painted with dark paint.

Sewage.

Where a sewer is not accessible, a septic tank for treatment of sewage is desirable.

Showers, Individual.

Individual showers where provided should be arranged as illustrated in Fig. 3.

Very few tubs should be used, as it is almost impossible to keep them and the floor underneath properly cleaned, but there are some men who prefer the tub to the shower.

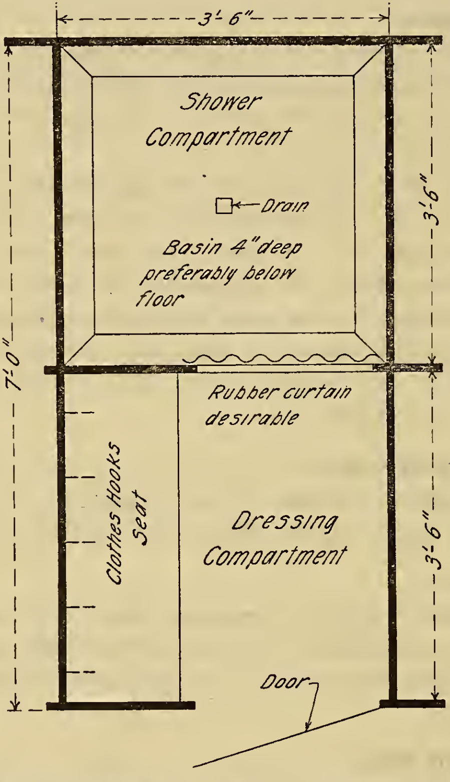


FIG. 3. ARRANGEMENT FOR SHOWER BATHS IN REST HOUSES.

Site.

Too often proper attention is not given to getting a desirable site, the fact being overlooked that the extra cost of such a site may be a very small part of the total. Questions of freedom from smoke and noise, of accessibility for supplies, water supply and sewage disposal, the chance of using exhaust steam from a shop heating plant for heating, an attractive outlook and the convenience of the men using it are all-important.

Toilets.

Breakage of Fixtures.

Much damage has been done by leakage from shower baths on the upper floors and especial care should be taken to prevent this.

General Toilet.

On the first floor or in the basement there should also be toilet facilities, including wash bowls. In connection with these facilities baths are desirable for those who do not wish assignment to a sleeping room. It is preferable to have them convenient to the lockers.

Separate Toilet for Women.

Where there is a possibility of women being employed, the house should be so designed that sleeping quarters and toilet facilities can be furnished for them separated from the rest of the building.

Separation of Fixtures.

For sanitary reasons the baths and washrooms should be separate from the other fixtures.

Slop Sinks.

At a convenient location on each sleeping floor a slop sink should be provided.

Toilet on Each Sleeping Floor.

There preferably should be toilet rooms and baths on each sleeping floor.

Toilet Room Floors.

The toilet room floors should be of composition or tile.

Urinals.

Urinals are the hardest fixtures to keep clean, and, as a rule, they should be omitted and water-closets with counterbalanced seats provided.

[9] ROOFINGS.

General.

In selecting roofing there should be considered:

(1) Chance of leaks due to character of construction.

(2) Probable life, including chance of damage by the elements and by wear from other causes.

(3) Fire-resisting value.

(4) Cost of maintenance.

(5) First cost.

---

[9] Adopted, Vol. 12, Part 1, 1911, pp. 588, 623; Vol. 14, 1913, pp. 839, 1084; Vol. 15, 1914, pp. 705-709, 1099; Vol. 16, 1915, pp. 746, 1149.

The important materials may be classified as follows:

Bituminous substances, applied with felts made of rags, asbestos or jute.

Clay and cement products and slate.

Metals.

They are laid in two general types—that for a flat roof, cemented together, as a coal-tar pitch-and-gravel roof or as an ordinary tin roof, and that for a steep roof, laid shingle fashion.

Flashings.

No contracts should be made for a built-up roof without a complete and positive specification including flashings, and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit.

Protection.

Where the roof is to be subjected to wear, and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

Workmanship.

In the laying of all roofings thoroughness in preparation of flashings and work around openings is of vital importance.

To get a satisfactory roof there must be a stable structure. Careful attention must be given to the design of gutters, and with some types, particularly, there must be systematic inspection and regular repairs. In buying a roof its fire-resisting qualities, to a considerable extent depending on the quantity of material as well as its quality, are of great importance. A building covered with a heavy coal-tar pitch and gravel roofing is a better fire risk than one covered with corrugated steel sheets or with a light ready roofing.

Inspection.

Thorough inspection of workmanship and material is recommended.

Life of Roof.

With proper materials and application, a life of from fifteen to twenty years can be expected with a flat roof.

Guarantees.

The practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

Saving in First Cost.

The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost.

Asphalts.

The asphalts are unsuitable for use in their natural state. They are ordinarily fluxed with products of petroleum.

Bituminous Materials.

General.

The common bituminous materials are:

Coal-tar pitch (the heavier distillates of bituminous coal).
Various asphalts (bitumens found naturally in the solid state).
Various petroleum products.
Various animal and vegetable residue.

Their peculiar value lies in the fact that they are practically insoluble in water; that they are elastic, adhesive and comparatively stable.

Blown Oils.

The blowing of air through a heated still of certain petroleum products produces "blown oils," which, while somewhat lacking in adhesive properties, are not easily susceptible to atmospheric changes and are valuable especially for roofing coatings.

Coal-Tar Pitch.

Coal-tar pitch is easily affected by heat and cold, is not acted upon at all by water, is easily worked, and if properly protected is very stable. It should ordinarily be used as it comes from the still, "straight run," of a consistency suitable to the climate and to proper application.

Combinations.

A single asphalt fluxed with a single oil is for most purposes a crude and unsatisfactory material. To secure the best results for any desired purpose, several oil and asphaltic substances must ordinarily be compounded. This requires skill and experience. Those properly made are for certain conditions invaluable, particularly for ready roofing, for which tar products are not suited.

The asphalt and petroleum products are not so readily affected by heat and cold as is coal-tar pitch, and lesser amounts of them are necessary to get good results. They are more expensive, require more skill in handling, and, when protected, some at least are to some extent liable to lose their life by drying out of the oil fluxes. Unprotected, they do much better than does coal-tar.

Petroleums.

The petroleums found in this country vary considerably, and grade roughly in quality, according to location from East to West. The California oils, with their asphaltic base, furnish materials especially valuable for roofing.

Water Gas-Tar Pitch.

Water gas-tar pitch, a by-product in the manufacture of water gas, which is enriched by gas from petroleum oils, resembles coal-tar. It is inferior to coal-tar for roofing purposes, and materials made from it should only be accepted in the low-priced products. It has more value as a saturant of felts than as a coating.

Kinds of Roofing.

Asbestos Shingles.

Shingles of asbestos and Portland cement are of value. They have some elasticity and can be laid tighter than slate. They come in a variety of shapes and colors and can be laid in various patterns.

Built-Up Roofs.

The bituminous roofings come ready to lay, or can be built up on the roof, using layers of saturated felt, mopped with pitch and properly protected.

The built-up roof is especially valuable for flat surfaces. It can be made as heavy as desired, and if properly laid and of good materials gives a roofing which by long experience has been shown to be economical and efficient.

For the flat roof built under average conditions, coal-tar pitch is recommended in preference to asphalt products. It is more easily handled, requiring less skill, and, while more material is necessary, it is still cheaper, and in our opinion more certain results can usually be expected from its use when laid by the average contractor. The large amount of material, while heavy has insulating value. Good results, however, can be expected from built-up roofs using good asphalt compounds, where laid by skilled workmen.

When the slope of the roof is over three inches to the foot, the application of a built-up roof becomes more difficult for both coal-tar and asphalt, it being harder to get even mopping, and there is more chance of accident for the men. The desirable straight-run coal tar pitch cannot be used, it being necessary to add some stiffening material, which is supposed to somewhat affect the life of the pitch. This must not be done except under supervision skilled in such work, and especial care must also be taken in the selection and application of the stone or slag coating.

Built-up roofs with a ready roofing for the coating sheet are proposed by various manufacturers. They should have their best value for steep slopes.

The advantage of a coal-tar pitch built-up roofing are such that it is recommended that where a permanent roof is desired, and where the character of the structure allows, the building be so designed as to allow its use. A flat roof makes an economical structure and has small fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper.

Cement Tile.

Small cement tile are not considered of much value, being brittle. Large cement tile, reinforced, laid without sheathing directly on the purlins, are in use on shops and freight houses and seem to have considerable merit. Glass can be introduced into them, avoiding the expense of skylights. It is not deemed advisable to recommend them for plastered or heated buildings or offices, where an occasional slight leak would be disastrous.

Felts.

The bituminous substances are used with felts whose qualities considerably affect the roofing. The ordinary felt is made of rags, mainly cotton. "Wool felt" is a misnomer. Asbestos felts, as compared with the rag felt, act less as a carrying medium for the bitumens, but rather as a protection to the layers of bitumen. They are not suited for use with coal-tar pitch, but are not injured by hot asphalt. They are more expensive than rag felts, but have some peculiar and valuable qualities. Burlap made from jute decays easily when not protected. It is used in a few ready roofings with rag felts to increase their tensile strength, the need of which is not generally agreed to.

Metallic Roofings.

Metallic roofings with steel as a base are not recommended for general use on permanent buildings.

They require continual maintenance. Galvanizing of steel seems to be well worth the expense. Tests of lead-covered steel sheets indicate good results.

Large sheets of corrugated galvanized steel can sometimes be used economically where the building is not to be heated.

Metallic Shingles.

Small metallic shingles of either copper, tin, galvanized steel plate or specially pure iron are not recommended for general use. They are very light in weight, but serve a purpose in the dry climate of the Southwest.

In using metals every effort should be made to secure those of good quality. The pure irons have value. Their virtues have, perhaps, been overstated, but they are not expensive, and experience seems to indicate considerable economy by their use as a substitute for wrought-iron and steel.

Ready Roofing.

The ready roofing has better value for the steeper roofs than for those of small pitch. It averages much cheaper than the built-up types. Most kinds, to get a fair life, require occasional recoating. For flat slopes they are hard to lay absolutely tight, and they are not economical for a permanent structure, but on slopes of from three inches to the foot up their use is more justifiable.

Ready or prepared roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance of more expensive roofings, is not justified. They are also of value for steep slopes, where a built-up coal-tar cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field.

The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

Ready Roofing Shingles.

On the steeper slopes the use of ready roofing shingles, properly reinforced so as to prevent curling up at the corners and fraying on the exposed edges and laid shingle fashion, is growing. They are supposed to give better results than the rolled goods, but cost more. They would seem at least to be worthy of investigation.

Slate and Tile.

Slate makes a good roof if of good quality and properly watched. It breaks easily and cannot be walked on without danger to the slate.

Tile of good quality gives good results. It is not so tight as slate, but does not break easily. It has architectural value, and its use is growing with improvement in the product and in the variety of colors.

Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of six inches to the foot or over, where expense is not the governing feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, eight inches to the foot should be the flattest slope allowed.

Wood Shingles.

Wood shingles are not desirable for a railroad structure on account of fire hazard.

[10] SECTION TOOL HOUSES.

Class A.

House, 14 by 20 feet, with long dimension parallel to track; house to have sliding door 8 feet in clear at extreme end on track side to permit the storing of handcar.

Class B.

House, 12 by 18 feet, with long dimension parallel to the track; house to have sliding door 8 feet in clear at extreme end of track side to permit the storing of handcar.

Class C.

House, 10 by 14 feet, with the short dimension parallel to the track, with double swinging doors, swinging out on the end nearest the track.

Building to be on wooden posts, unless the location can be permanent, in which case brick or concrete piers may be substituted.

---

[10] Adopted, Vol. 11, Part 2, 1910, pp. 1044-1046, 1054; Vol. 16, 1915, pp. 746, 1149.

COMMITTEE VII.

WOODEN BRIDGES AND TRESTLES.

[1] DEFINITIONS.

General

Wooden Trestle.—A wooden structure composed of upright members supporting simple horizontal members or beams, the whole forming a support for loads applied to the horizontal members.

Frame Trestle.—A structure in which the upright members or supports are framed timbers.

Pile Trestle.—A structure in which the upright members or supports are piles.

Bent.—The group of members forming a single vertical support of a trestle, designated as pile bent where the principal members are piles, and as framed bent where of framed timbers.

Post.—One of the vertical or battered members of the bent of a framed trestle.

Pile.—(See definition under subject of Piles and Pile Driving.)

Batter.—A deviation from the vertical in upright members of a bent.

Cap.—A horizontal member upon the top of piles or posts, connecting them in the form of a bent.

Sill.—The lowest horizontal member of a framed bent.

Mud-Sill or Sub-Sill.—A timber bedded in the ground to support a framed bent.

Intermediate Sill.—A horizontal member in the plane of the bent forming the cap of a lower section and the sill of an upper section.

Sway Brace.—A member bolted or spiked to the bent and extending diagonally across its face.

Longitudinal Strut or Girt.—A stiffening member running horizontally, or nearly so, from bent to bent.

Longitudinal X Brace.—A member extending diagonally from bent to bent in a vertical or battered plane.

Sash Brace.—A horizontal member secured to the posts or piles of a bent.

---

[1] Adopted, Vol. 6, 1905, pp. 35, 36, 42, 55-67; Vol. 7, 1906, pp. 683, 684; Vol. 11, Part 1, 1910, pp. 178, 228; Vol. 16, 1915, pp. 894, 1179; Vol. 21, 1920, pp. 1281, 1434.

Stringer.—A longitudinal member extending from bent to bent and supporting the track.

Jack Stringer.—A stringer placed outside of the line of main stringers.

Bridge Tie.—A transverse timber resting on the stringers and supporting the rails.

Inner Guard Rail.—A longitudinal member, usually a metal rail, secured on top of the ties inside of the track rail, to guide derailed car wheels.

Guard Timber.—A longitudinal timber placed outside of the track rail, to maintain the spacing of the ties.

Packing Block.—A small member, usually wood, used to secure the parts of a composite member in their proper relative positions.

Packing Spool or Separator.—A small casting used in connection with packing bolts to secure the several parts of a composite member in their proper relative positions.

Drift Bolt.—A piece of round or square iron of specified length, with or without head or point, driven as a spike.

Dowel.—An iron or wooden pin, extending into, but not through, two members of the structure to connect them.

Shim.—A small piece of wood or metal placed between two members of a structure to bring them to a desired relative elevation.

Fish-Plate.—A short piece lapping a joint, secured to the side of two members, to connect them end to end.

Bulkhead.—Timbers placed against the embankment side of an end bent to retain the embankment.

[2]Piles and Pile Driving.

Pile.—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

The usual functions of a pile are: (*a*) To carry a superimposed load; (*b*) To compact the surrounding ground; (*c*) To form a wall to exclude water and soft material, or to resist the lateral pressure of adjacent ground.

Head of Pile.—The upper end of a pile.

Foot of Pile.—The lower end of a pile.

Butt of Pile.—The larger end of a pile.

Tip of Pile.—The smaller end of a pile.

Bearing Pile.—One used to carry a superimposed load.

---

[2] Adopted, Vol. 10, 1909, p. 565; Vol. 16, 1915, pp. 894, 1179; Vol. 21, 1920, pp. 1282, 1434.

Screw Pile.—One having a broad-bladed screw attached to its foot to provide a larger bearing area.

Disc Pile.—One having a disc attached to its foot to provide a larger bearing area.

Batter Pile.—One driven at an inclination to resist forces which are not vertical.

Sheet Piles.—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and soft materials; or driven to resist the lateral pressure of adjacent ground.

Pile Driver.—A machine for driving piles.

Hammer.—A weight used to drive piles.

Drop Hammer.—One which is raised by means of a rope and then allowed to drop.

Steam Hammer.—One which is automatically operated by the action of a steam cylinder and piston supported in a frame which rests on the pile.

Leads.—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.

Pile Cap, Hood or Bonnet.—A block used to protect the head of a pile and to hold it in the leads during driving.

Ring.—A metal hoop used to bind the head of a pile during driving.

Shoe.—A metal protection for the point or foot of a pile.

Follower.—A member interposed between the hammer and pile to transmit blows to the latter when below the foot of the leads.

[3]SPECIFICATIONS FOR TIMBER PILES.

Railroad Heart Grade.

1. This grade includes white, burr, and post oak; dense pine, Douglas fir, tamarack, Eastern white and red cedar, chestnut, Western cedar, redwood and cypress.

2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects, which may materially impair their strength or durability. In Eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed.

3. Piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn

---

[3]Adopted, Vol. 10, 1909, pp. 537, 541, 542, 603-611.

from the center of the butt to the center of the tip shall lie within the body of the pile.

4. Unless otherwise allowed, piles must be cut when sap is down. Piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

5. The minimum diameter at the tips of round piles shall be 9 inches for lengths not exceeding 30 feet; 8 inches for lengths over 30 feet but not exceeding 50 feet, and 7 inches for lengths over 50 feet. The minimum diameter at one-quarter of the length from the butt shall be 12 inches and the maximum diameter at the butt 20 inches.

6. The minimum width of any side of the tip of a square pile shall be 9 inches for lengths not exceeding 30 feet; 8 inches for lengths over 30 feet but not exceeding 50 feet, and 7 inches for lengths over 50 feet. The minimum width of any side at one-quarter of the length from the butt shall be 12 inches.

7. Square piles shall show at least 80 per cent. heart on each side at any cross-section of the stick, and all round piles shall show at least 10½ inches diameter of heart at the butt.

Railroad Falsework Grade.

8. This grade includes red and all other oaks not included in Railroad Heart grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine or any sound timber that will stand driving.

9. The requirements for size of tip and butt taper and lateral curvature are the same as for Railroad Heart grade.

10. Unless otherwise specified piles need not be peeled.

11. No limits are specified as to the diameter or proportion of heart.

12. Piles which meet the requirements of Railroad Heart grade except the proportion of heart specified will be classed as Railroad Falsework grade.

[4]PILE DRIVING—PRINCIPLES OF PRACTICE.

(1) A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

---

[4] Adopted, Vol. 12, 1911, Part 1, pp. 279, 307; Vol. 16, 1915, pp. 894, 1181.

(2) Soil consisting wholly or chiefly of sand is most favorable to the use of the water jet.

(3) In harder soils containing gravel the use of the jet may be advantageous, if sufficient volume and pressure be provided.

(4) In clay it may be economical to bore several holes in the soil with the aid of the jet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven.

(5) In general, the water jet should not be attached to the pile, but handled separately.

(6) Two jets will often succeed where one fails. In special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

(7) Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immediate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

(8) A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

(9) The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

(10) There is danger from overdriving when the hammer begins to bounce. Overdriving is also indicated by the bending, kicking or staggering of the pile.

(11) The brooming of the head of the pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

(12) The steam hammer is usually more effective than the drop hammer in securing the penetration of a wooden pile without injury, because of the shorter interval between blows.

(13) Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the drop hammer. This is especially true in the case of sheet piling which is intended to prevent the passage of water. In some cases also the jet should not be used.

(14) In general, the resistance of piles, penetrating soft material, depending solely upon skin friction, is materially increased after a period

of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

(15) Where a pile penetrates a soft yielding material and bears upon hard stratum at its foot, its strength should be determined as a column; omitting the resistance, if any, due to skin friction.

(16) Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

(17) In case the piles in a foundation are expected to act as columns, the results of loading test piles should not be depended upon unless they are sufficient in number to insure their action in a similar manner; and unless they are stayed against lateral motion.

(18) Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

(19) Where the resistance of piles depends mainly upon skin friction it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area.

(20) Where piles will foot in a hard stratum, investigation should be made to determine that this stratum is of sufficient depth and strength to carry the load.

(21) Timber piles may be advantageously pointed, in some cases to a 4-inch or 6-inch square at the end.

(22) Piles should not be pointed when driven into soft material.

(23) Shoes should be provided for piles when the driving is very hard, especially in riprap or shale. These shoes should be so constructed as to form an integral part of the pile.

(24) The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as in holding it in position during driving.

[5]PILE RECORD FORM.

Size 8½x11 or 8x10½ inches. Form M. W. 701.

North and South Railroad.

Pile Record of Bridge..

LOCATION..

Weight and Kind of Hammer..........................**Date**..............**19**....

Bents Numbered from North or East End **Piles numbered from Left to Right**

Date	Bent No.	No. of Pile	Size of Pile			Kind of Wood	Cut-off	Base-rail to Ground	Total Penetrat.	Av. Last Five Blows		Kind of Soil	Remarks
			Tip End	Butt End	Length					Drop of Ham'r	Penetrat.		

---

[5] Adopted, Vol. 12, Part 1, 1911, pp. 278, 307.

[6]SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND FRAME TRESTLES OF UNTREATED MATERIAL TO BE BUILT UNDER CONTRACT.

Site.

1. The trestle to be built under these specifications is located on the line of .... Railway at ....
County of ....State of ....

General Description.

2. The work to be done under these specifications covers the construction of a .... track wooden trestle about .... feet long and an average of .... feet high.

General Clauses.

3. The contractor shall furnish all necessary labor, tools, machinery, supplies, temporary staging and outfit required. He shall build the complete trestle ready for the track rails, in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications, to the satisfaction and acceptance of the Engineer of the Railway Company.

4. The workmanship shall be of the best quality in each class of work. Details, fastenings and connections shall be of the best method of construction in general use on first-class work.

5. Holes shall be bored for all bolts. The depth of the hole and the diameter of the augur shall be as specified by the Engineer.

6. Framing shall be accurately fitted. No blocking or shimming will be allowed in making joints. Timbers shall be cut off with the saw; no axe to be used.

7. Joints and points of bearing, for which no fastening is shown on the plans, shall be fastened as specified by the Engineer.

8. The Engineer or his authorized agents shall have full power to cause any inferior work to be condemned, and taken down or altered, at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men must be replaced by the contractor at his own expense.

9. Figures shown on the plans shall govern in preference to scale measurements. If any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the Engineer for instructions. These specifications and the plans are intended to coin-

---

[6] Adopted, Vol. 8, 1907, pp. 397-400, 442-450.

cide, and if any question arises as to the proper interpretation of the plans or specifications, it shall be referred to the Engineer for a ruling.

10. The contractor shall, when required by the Engineer, furnish a satisfactory watchman to guard the work.

11. On the completion of the work, all refuse material and rubbish that may have accumulated on top and under and near the trestle, by reason of its construction, shall be removed by the contractor.

Detail Specifications.

12. Piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the Engineer, pile butts shall be banded with iron or steel for driving, and the tips shod with suitable iron or steel shoes. Such shoes will be furnished by the Railway Company.

13. Piles shall be driven to firm bearing, satisfactory to the Engineer; or until five blows of a hammer weighing 3000 lb., falling 15 feet (or a hammer and fall producing the same mechanical effect), are required to cause an average penetration of ½ inch per blow, except in soft bottom, where special instructions will be given.

14. Batter piles shall be driven to the inclination shown by the plans, and shall require but slight bending before framing.

15. Butts of all piles in a bent shall be sawed off to one plane and trimmed so as not to leave any horizontal projection outside of the cap.

16. Piles injured in driving, or driven out of place, shall either be pulled out or cut off, and replaced by new piles.

Caps.

17. Caps shall be sized and brought to a uniform thickness and even bearing on piles or posts. The side with most sap shall be placed downward.

Posts.

18. Posts shall be sawed to proper length for their position (vertical or batter), and to even bearing on cap and sill.

Sills.

19. Sills shall be sized at the bearing of posts to one plane.

Sash and Sway Braces.

20. Sash and sway bracing shall be properly framed and securely fastened to piles or posts. When necessary, filling pieces shall be used between the braces and the piles of a bent on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

Longitudinal Braces.

21. Longitudinal X braces shall be properly framed and securely fastened to piles or posts.

Girts.

22. Girts shall be properly framed and securely fastened to caps, sub-sills, intermediate sills, posts or piles, as the plans may require.

Stringers.

23. Stringers shall be sized to a uniform depth at supports. The edges with most sap shall be placed downward.

Jack Stringers.

24. Jack stringers, if required on the plans, shall be neatly framed on caps, and their tops shall be in the same plane as the track stringers.

Ties.

25. Ties shall be sized to a uniform thickness and shall be placed with the rough side upward. They shall be spaced regularly and cut to even length and line, as called for on the plans.

Guard Timbers.

26. Guard timbers shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

Bulkheads.

27. Bulkheads shall be of sufficient dimensions to keep the embankment clear of the caps, stringers and ties, at the end bents of the trestle. There shall be a space of not less than 2 inches between the back of the end bent and the face of the bulkhead. The projecting ends of the bulkhead shall be sawed off to conform to the slope of the embankment, unless otherwise specified.

Time of Completion.

28. The work shall be completed in all its parts on or before
.... 19....

Payments.

29. Payments will be made under the usual regulations of the Railway Company.

[7]USE OF GUARD RAILS AND GUARD TIMBERS FOR WOODEN BRIDGES AND TRESTLES.

(1) It is recommended as good practice to use guard timbers on all open-floor bridges, and same should be so constructed as to properly space the ties and hold them securely in their places.

(2) It is recommended that the guard timber and the inner guard rail, when used, shall be so spaced in reference to the track rail that a derailed truck will strike the inner guard rail without striking the guard timber. The inner guard rail should not be higher nor more than one inch lower than the running rail.

(3) It is recommended as good practice in the installation of inner guard rails to extend them beyond the ends of the bridges for such distance as is required by local conditions, but that this distance, in any case, be not less than 50 feet; that inner guard rails be fully spiked to every tie, and spliced at every joint; that the inner guard rails be some form of metal section; and that the ends be beveled, bent down, or otherwise protected against direct impact with moving parts of equipment.

(4) It is recommended as good practice to use inner guard rails on all open-floor and on the outside tracks of all solid-floor bridges and similar structures longer than 20 feet in main-line tracks, and on similar bridges and structures in branch-line tracks on which the speed of trains is 20 miles per hour or more.

[8]USE OF LAG SCREWS IN TRESTLE CONSTRUCTION.

(1) Lag screws require greater care than ordinary bolts and nuts to properly install, but are cheaper on account of ease of general maintenance.

(2) Lag screws, where properly applied, hold ties from bunching equally as well as bolts and nuts, and better than daps, in guard timbers.

(3) If the lag screws are tightened after timber has shrunk, there is less cost of maintenance than with bolts and nuts.

(4) Use of lag screws renders unnecessary the dapping of guard timbers, and, therefore, decreases cost of trestles without impairing quality.

---

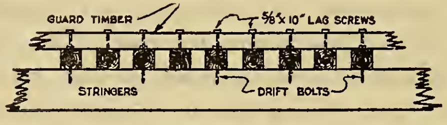
[7] Adopted, Vol. 14, 1913, pp. 652, 653, 1136-1143; Vol. 15, 1914, pp. 403, 1036-1044; Vol. 21, 1920, pp. 1285, 1434.

[8] Adopted, Vol. 19, 1918, pp. 584, 608, 1225.

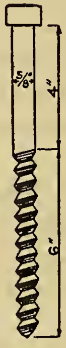
(5) Surfacing (sizing) ties and guard timbers is better construction than dapping.

(6) For proper application of lag screws, holes in guard timbers should be bored with auger bits 1/16 in. less in diameter and holes in ties ¼ in. less in diameter than the nominal size of lag screws used.

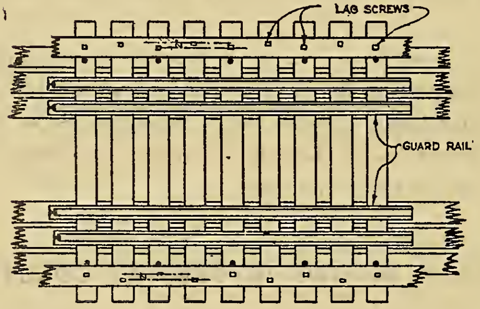
(7) Lag screws must be screwed in, not driven.



ELEVATION.



LAG SCREW.



PLAN

NOTE.—Ties and guard timbers to be sized one dimension. Omit dapping of guard timbers and ties. Use lag screws in every tie. Holes to be bored for lag screws one inch deeper than penetration of lag screw. Holes to be bored 1/16 in. smaller than diameter of lag in guard timber, and ¼ in. smaller than diameter of lag in ties. Lag screws must not be driven but screwed to position. Fasten alternate ties to stringers. Lag screws to be staggered 2 in. in guard timbers.

[9]SPECIFICATIONS FOR METAL DETAILS USED IN WOODEN BRIDGES AND TRESTLES.

Wrought-Iron.

1. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per square inch, an elongation of 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

Steel.

2. Steel shall be made by the open-hearth process and shall be of uniform quality. It shall contain not more than 0.05 per cent. sulphur. If made by the acid process it shall contain not more than 0.06 per cent. phosphorus; and if made by the basic process, not more than 0.04 per cent. phosphorus. When tested in specimens of the form of Fig. 1, or full-sized pieces of the same length, it shall have a desired ultimate tensile strength of 60,000 lbs. per square inch. If the ultimate strength varies more than 4000 lbs. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5000 lbs. of the desired ultimate. It shall have a minimum percentage of elongation in 8 inches of $\frac{1,500,000}{\text{ultimate tensile strength}}$; and shall bend cold without fracture 180 degrees flat. The fracture for tensile tests shall be silky.

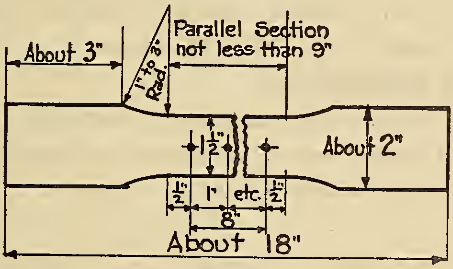


Fig. 1.

Cast-Iron.

3. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If

---

[9]Adopted, Vol. 7, 1906, pp. 692-694, 719-724; Vol. 11, 1910.

tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ inches in diameter and 15 inches long. The transverse test shall be made on a supported length of 12 inches, with load at middle. The minimum breaking load so applied shall be 2900 lbs., with a deflection of at least 1/10 inch before rupture.

Bolts.

4. Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. Threads shall be cut according to U. S. standards.

Drift Bolts.

5. Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on plans.

Spikes.

6. Spikes shall be of wrought-iron or steel, square or round, as called for on the plans. Steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 inches; if greater lengths are required, wrought or steel spikes shall be used.

Packing Spools or Separators.

7. Packing spools or separators shall be of cast-iron, made to size and shape called for on plans. The diameter of hole shall be ⅛ inch larger than diameter of packing bolts.

Cast Washers.

8. Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and its thickness equal to the diameter of bolt. The diameter of hole shall be ⅛ inch larger than the diameter of the bolt.

Wrought Washers.

9. Wrought washers shall be of wrought-iron or steel, the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼ inch thick. The hole shall be ⅛ inch larger than the diameter of the bolt.

Special Castings.

10. Special castings shall be made true to pattern, without wind, free from flaws and excessive shrinkage; size and shape to be as called for by the plans.

[10]RELATIVE ECONOMY OF REPAIRS AND RENEWALS OF WOODEN BRIDGES AND TRESTLES.

It is good practice to repair wooden bridges and trestles by parts until such time as the general condition of the structure requires entire renewal.

[11]COMPARATIVE MERITS OF BALLAST DECK AND REINFORCED CONCRETE TRESTLES.

(1) While in certain locations there is little probability of fire loss in creosoted ballast deck timber trestles, yet due to the very nature of the material used the reinforced concrete trestle has a decided advantage.

(2) The concrete structure is slightly superior to the timber structure for bridging waterways subject to flood currents, or wide fluctuations in elevation of water surface.

(3) Although the concrete trestle may possibly afford better service qualities than the wooden trestle, the matter is so intangible in character as to preclude a definite statement of relative merit.

(4) Where selection of type of trestle is optional and not influenced by other considerations, neither type of trestle has the advantage of the other in the matter of appearance.

(5) Notwithstanding the fact that the two materials are, with certain limitations, equally suitable for the construction of trestles, the use of concrete is more in accord with the theory of conservation of natural resources and industrial economy.

(6) Adoption of either type should be the result of carefully weighing, for each individual bridge, the greater economy of the timber trestle against the several advantages of the concrete not susceptible of mathematical demonstration.

(7) Creosoted timber trestles are more economical than concrete, except when the cost of the concrete structure is less than one and one-half times the cost of the wooden structure.

---

[10] Adopted, Vol. 16, 1915, pp. 891, 1179.
[11] Adopted, Vol. 19, 1918, pp. 592, 603, 1223.

Analysis No. 1.

CAPITALIZATION METHOD—COMPARATIVE ECONOMIC VALUE—BALLAST DECK TRESTLES.

w = Cost of Wooden Trestle.
c = Cost of Concrete Trestle.
r = Rate of interest.
m = Life in years of wooden trestle.
n = " " " " concrete "
x = Amount capitalized which will replace wooden trestle every m years.
y = " " " " " concrete " " n "
f = Ratio of first cost of concrete trestle to first cost of wooden trestle to produce equal ultimate economy, that is

$f = \frac{c}{w}$ or $fw = c$

Then $x(1+r)^m = w+x$ and $y(1+r)^n = c+y$, whence $x = \frac{w}{[(1+r)^m-1]}$

$$\text{and } y = \frac{c}{[(1+r)^n-1]} = \frac{fw}{[(1+r)^n-1]}$$

To produce equivalent ultimate economy $w+x=c+y$, which by substituting values of x and y gives

$$w + \frac{w}{[(1+r)^m-1]} = fw + \frac{fw}{[(1+r)^n-1]}$$

Dividing by w and solving for f it is found that

$$f = \frac{1+\frac{1}{[(1+r)^m-1]}}{1+\frac{1}{[(1+r)^n-1]}}$$

which is variable only with respect to m and n the assumed lives of wood and concrete. By using as an argument first cost of wooden trestle with a constant life regardless of such cost, the first cost of a concrete trestle with a life of n years is found by applying to cost of wooden trestle the coefficient f determined for n years.

Analysis No. 2.

SINKING FUND METHOD—COMPARATIVE ECONOMIC VALUE—BALLAST DECK TRESTLES.

W = Cost of Wooden Trestle.
C = Cost of Concrete Trestle.
r = Rate of Interest on Cost of Trestle.
r' = " " " earned by Sinking Fund.
m = Life, in years, of Wooden Trestle.
n = " " " " Concrete "
a = Annual Contribution to Sinking Fund required to reproduce wooden trestle at end of m years.
b = Wr = Annual interest on original cost of Wooden Trestle.
d = Annual Contribution to Sinking Fund required to reproduce concrete trestle at end of n years.
e = Cr = Annual interest on original cost of Concrete Trestle.
E = $a+b$ = Annual expense of wooden trestle.
E = $d+e$ = " " " concrete "
F = Ratio of first cost of concrete trestle to first cost of wooden trestle to produce equal ultimate economy; that is
$F = \frac{C}{W}$ or $FW = C$

Then $E = Wr + \dfrac{W}{(1+r')^{m-1} + (1+r')^{m-2} \ldots\ldots + 1}$

and $E' = Cr + \dfrac{C}{(1+r')^{n-1} + (1+r')^{n-2} \ldots\ldots + 1}$

To produce equal economy $E = E'$ and by substituting values of E, E' and C and solving for F.

$$= \frac{r + \dfrac{1}{(1+r')^{m-1} + (1+r')^{m-2} + 1}}{r + \dfrac{1}{(1+r')^{n-1} + (1+r')^{n-2} + 1}} = \frac{r + \dfrac{}{\dfrac{(1+r')^m - 1}{(1+r') - 1}}}{r + \dfrac{1}{\dfrac{(1+r')^n - 1}{(1+r') - 1}}} = \frac{r + \dfrac{r'}{(1-r')^m - 1}}{r + \dfrac{r'}{(1+r')^n - 1}}$$

Analysis No. 3.

COMPARISON OF METHODS—COMPARATIVE ECONOMIC VALUE—BALLAST DECK TRESTLES.

W = Cost of Wooden Trestle.
C = Cost of Concrete Trestle.
r = Rate of Interest on Cost of Trestle.
r' = " " " earned by Sinking Fund.
m = Life, in years, of Wooden Trestle.
n = " " " " Concrete Trestle.
f = Ratio of first cost of Concrete Trestle to first cost of Wooden Trestle to produce equal ultimate economy by capitalization method, that is

$$f = \frac{C}{W} \quad \text{or} \quad fW = C$$

F = Ratio of first cost of Concrete Trestle to first cost of Wooden Trestle to produce equal ultimate economy by sinking fund method, that is

$$F = \frac{C}{W} \quad \text{or} \quad FW = C$$

By capitalization method $$f = \frac{1 + \frac{1}{(1+r)^m - 1}}{1 + \frac{1}{(1+r)^n - 1}} \qquad (1)$$

By sinking fund method $$F = \frac{r + \frac{r'}{(1+r')^m - 1}}{r + \frac{r'}{(1+r')^n - 1}} \qquad (2)$$

A comparison shows the two methods to be identical if same rate of interest is earned on sinking fund as that paid on cost of trestle, for in that case $r' = r$ and by substituting r for r' in (2) it becomes

$$F = \frac{1 + \frac{1}{(1+r)^m - 1}}{1 + \frac{1}{(1+r)^n - 1}} \qquad (3)$$

which is identical with (1) and $f = F$ It is therefore evident that regardless of what rate of interest is used the two methods are productive of the same results provided only that the same rate of interest be applied to sinking fund as to original cost of trestle.

Analysis No. 5.

REPLACEMENT METHOD—COMPARATIVE ECONOMIC VALUE—BALLAST DECK TRESTLES.

w = Cost of Wooden Trestle.
c = " " Concrete "
r = Rate of Interest
m = Life in years of Wooden Trestle.
n = " " " " Concrete "
A = Cost of Wooden Trestle for a period of n years.
B = " " Concrete " " " " " n "
f' = Ratio of first cost of concrete trestle to first cost of wooden trestle to produce equal ultimate economy, that is
$f' = \frac{c}{w}$ or $f'w = c$

Then $A = w\left[(1+r)^m + (1+r)^{2m} \ldots\ldots + (1+r)^{n-2m} + (1+r)^{n-m} + (1+r)^n\right] = w\frac{(1+r)^{n+m} - (1+r)^m}{(1+r)^m - 1}$

and $B = c(1+r)^n$

To produce equivalent ultimate economy $A = B$, which by substituting values of A, B and c gives

$$f'w(1+r)^n = w\frac{(1+r)^{n+m} - (1+r)^m}{(1+r)^m - 1}$$

Dividing by w and solving for f' it is found that

$$f' = \frac{\dfrac{(1+r)^{n+m} - (1+r)^m}{(1+r)^m - 1}}{(1+r)^n} = \frac{(1+r)^{n+m} - (1+r)^m}{(1+r)^{n+m} - (1+r)^n} = \frac{\dfrac{(1+r)^{n+m} - (1+r)^m}{[(1+r)^n - 1][(1+r)^m - 1]}}{\dfrac{(1+r)^{n+m} - (1+r)^n}{[(1+r)^n - 1][(1+r)^m - 1]}}$$

$$= \frac{\dfrac{(1+r)^m}{(1+r)^m - 1}}{\dfrac{(1+r)^n}{(1+r)^n - 1}} = \frac{1 + \dfrac{1}{(1+r)^m - 1}}{1 + \dfrac{1}{(1+r)^n - 1}},$$

which is identical to the value of f in the Capitalization Method

COMPARATIVE COST OF INSTALLATION OF BALLAST DECK TRESTLES PER LINEAR FOOT TO PRODUCE EQUIVALENT ECONOMIC VALUE; INTEREST AT 6 PER CENT. PER ANNUM. ASSUMING CREOSOTED TIMBER TRESTLE WILL SERVE 20 YEARS.

Creosoted Timber Service Life 20 Years	Justifiable Expenditure for Concrete Serviceable for							
	30 Yrs.	40 Yrs.	50 Yrs.	60 Yrs.	70 Yrs.	80 Yrs.	90 Yrs.	100 Yrs.
$10 00	$12 00	$13 09	$13 74	$14 09	$14 28	$14 39	$14 46	$14 49
11 00	13 20	14 39	15 12	15 50	15 71	15 83	15 90	15 94
12 00	14 40	15 70	16 49	16 91	17 14	17 26	17 35	17 39
13 00	15 60	17 01	17 86	18 32	18 57	18 70	18 79	18 83
14 00	16 80	18 32	19 24	19 73	20 00	20 14	20 24	20 28
15 00	18 00	19 63	20 61	21 14	21 43	21 58	21 68	21 73
16 00	19 20	20 94	21 99	22 54	22 86	23 02	23 13	23 18
17 00	20 40	22 24	23 36	23 95	24 28	24 46	24 57	24 63
18 00	21 60	23 55	24 74	25 36	25 71	25 90	26 02	26 09
19 00	22 80	24 86	26 11	26 77	27 14	27 34	27 46	27 53
20 00	24 00	26 17	27 48	28 18	28 57	28 77	28 91	28 98

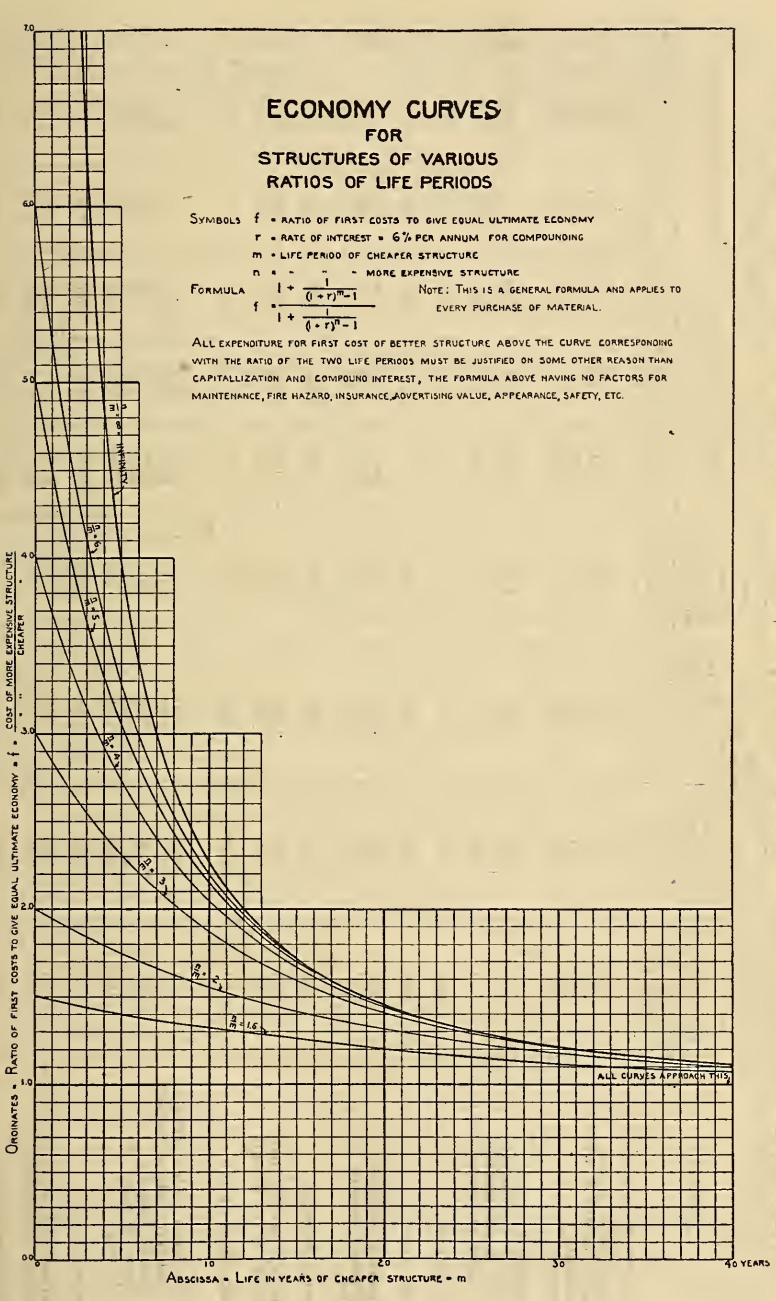
COMPARATIVE COST OF INSTALLATION OF BALLAST DECK TRESTLES PER LINEAR FOOT TO PRODUCE EQUIVALENT ECONOMIC VALUE; INTEREST AT 6 PER CENT. PER ANNUM. ASSUMING CREOSOTED TIMBER TRESTLE WILL SERVE 25 YEARS.

Creosoted Timber Service Life 25 Years	Justifiable Expenditure for Concrete Serviceable for							
	30 Yrs.	40 Yrs.	50 Yrs.	60 Yrs.	70 Yrs.	80 Yrs.	90 Yrs.	100 Yrs.
$10 00	$10 77	$11 74	$12 33	$12 64	$12 82	$12 91	$12 97	$13 00
11 00	11 84	12 91	13 56	13 91	14 10	14 20	14 27	14 30
12 00	12 92	14 09	14 80	15 17	15 38	15 49	15 56	15 60
13 00	14 00	15 26	16 03	16 44	16 66	16 78	16 86	16 90
14 00	15 07	16 44	17 26	17 70	17 94	18 07	18 16	18 20
15 00	16 15	17 61	18 50	18 96	19 23	19 36	19 45	19 50
16 00	17 23	18 79	19 73	20 23	20 51	20 65	20 75	20 80
17 00	18 31	19 96	20 96	21 49	21 79	21 94	22 05	22 10
18 00	19 38	21 13	22 19	22 76	23 07	23 24	23 34	23 40
19 00	20 46	22 31	23 43	24 02	24 35	24 53	24 64	24 70
20 00	21 54	23 48	24 66	25 29	25 63	25 82	25 94	26 00

RATIO OF INSTALLATION COSTS OF STRUCTURES TO PRODUCE EQUIVALENT ULTIMATE ECONOMY IN THEIR PERPETUAL MAINTENANCE. BASED ON AN INTEREST RATE OF 6 PER CENT. PER ANNUM FOR CAPITAL INVESTED THEREIN, AND NEGLECTING COSTS OF REPAIRS.

Service Life Years	5	10	15	20	25	30	40	50	60	70	80
100	3.94491	2.25779	1.71099	1.44880	1.29994	1.20725	1.10721	1.05429	1.02822	1.01422	1.00702
90	3.93569	2.25251	1.70699	1.44551	1.29690	1.20442	1.10462	1.05182	1.02582	1.01185	1.00467
80	3.91741	2.24205	1.69906	1.43869	1.29087	1.19883	1.09949	1.04694	1.02105	1.00715	1.00000
70	3.88960	2.22613	1.68700	1.42848	1.28171	1.19032	1.09168	1.03951	1.01380	1.00000	
60	3.83663	2.19582	1.66403	1.40903	1.26426	1.17411	1.07682	1.02771	1.00000		
50	3.74177	2.14153	1.62288	1.37419	1.23300	1.14508	1.05019	1.00000			
40	3.56295	2.03918	1.54532	1.30852	1.17407	1.09035	1.00000			90	100
30	3.26770	1 87020	1.41727	1.20008	1.07678	1.00000					
25	3.03470	1.73684	1.31621	1.11451	1.00000						
20	2.72290	1.55840	1.18098	1.00000						1.00234	1.00000
15	2.30564	1.31958	1.00000							1.00000	
10	1.74725	1.00000									
5	1.00000										

This statement is developed from formula in Analysis No. 1.



ECONOMY CURVES
FOR
STRUCTURES OF VARIOUS RATIOS OF LIFE PERIODS

SYMBOLS
f = RATIO OF FIRST COSTS TO GIVE EQUAL ULTIMATE ECONOMY
r = RATE OF INTEREST = 6% PER ANNUM FOR COMPOUNDING
m = LIFE PERIOD OF CHEAPER STRUCTURE
n = " " " MORE EXPENSIVE STRUCTURE

FORMULA

$$f = \frac{1 + \frac{1}{(1+r)^m - 1}}{1 + \frac{1}{(1+r)^n - 1}}$$

NOTE: THIS IS A GENERAL FORMULA AND APPLIES TO EVERY PURCHASE OF MATERIAL.

ALL EXPENDITURE FOR FIRST COST OF BETTER STRUCTURE ABOVE THE CURVE CORRESPONDING WITH THE RATIO OF THE TWO LIFE PERIODS MUST BE JUSTIFIED ON SOME OTHER REASON THAN CAPITALIZATION AND COMPOUND INTEREST, THE FORMULA ABOVE HAVING NO FACTORS FOR MAINTENANCE, FIRE HAZARD, INSURANCE, ADVERTISING VALUE, APPEARANCE, SAFETY, ETC.

7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40 YEARS
$\frac{n}{m}$ = ∞ INFINITY
$\frac{n}{m}$ = 6
$\frac{n}{m}$ = 5
$\frac{n}{m}$ = 4
$\frac{n}{m}$ = 3
$\frac{n}{m}$ = 2
$\frac{n}{m}$ = 1.6
ALL CURVES APPROACH THIS
ORDINATES = RATIO OF FIRST COSTS TO GIVE EQUAL ULTIMATE ECONOMY = f = COST OF MORE EXPENSIVE STRUCTURE : CHEAPER
ABSCISSA = LIFE IN YEARS OF CHEAPER STRUCTURE = m

[12]WORKING STRESSES PERMISSIBLE FOR STRUCTURAL TIMBERS (Pounds per Square Inch)

Species	Bending.				Compression.					
	Allowable stress in extreme fiber.			Allowable horizontal shear stress.	Allowable stress parallel to grain "Short Columns."			Allowable stress perpendicular to grain.		
	Damp or wet location (docks, piling, and sills)	Outside, not in contact with soil (bridges and open sheds)	Under shelter in a dry location (factories and warehouses)	All locations	Wet location	Outside location	Dry location	Wet location	Outside location	Inside location
Cedar, western red	750	800	900	80	650	700	700	125	150	200
Cedar, northern white	600	650	750	70	450	500	550	100	140	175
Chestnut	700	850	950	90	600	700	800	150	200	300
Cypress	900	1100	1300	100	800	1100	1100	225	250	350
Douglas fir—										
No. 1 structural	1100	1400	1600	100	900	1100	1200	225	250	350
No. 2 structural	900	1100	1300	90	800	900	1000	200	225	300
Rocky Mountain region	700	900	1100	85	700	800	800	200	225	275
Fir, balsam	600	750	900	70	500	600	700	100	125	150
Gum, red	800	900	1100	100	650	750	800	150	200	300
Hemlock, western	900	1100	1300	75	800	900	900	200	225	300
Hemlock, eastern	800	900	1000	70	600	700	700	200	225	300
Hickory	1200	1500	1900	140	1000	1200	1500	350	400	600
Larch, western	900	1100	1200	100	800	1000	1100	200	275	325
Maple, sugar or hard	1000	1300	1500	150	900	1100	1200	300	375	500
Maple, silver or soft	700	900	1000	100	600	700	800	200	250	350
Oak, white or red	1000	1200	1400	125	800	900	1000	300	375	500
Pine—										
Southern yellow (dense)	1100	1400	1600	125	900	1100	1200	225	250	350
Southern yellow (sound)	900	1100	1300	105	800	900	1000	200	225	300
Eastern white	750	800	900	85	650	750	750	125	150	250
Western white	750	800	900	85	650	750	750	125	150	250
Norway	800	1000	1100	85	700	800	800	150	175	300
Redwood	800	1000	1200	70	750	900	1000	125	150	250
Spruce, red, white and Sitka	800	900	1100	85	650	750	800	125	150	250
Spruce, Engelmann	500	650	750	70	450	550	600	100	140	175
Tamarack, eastern	900	1100	1200	95	800	900	1000	200	225	300

---

[12] Adopted, Vol. 21, 1920, pp. 1337, 1434.

[13]SPECIFICATIONS AND CLASSIFICATION AND GRADING RULES FOR LUMBER AND TIMBER TO BE USED IN THE CONSTRUCTION AND MAINTENANCE OF WAY DEPARTMENTS OF RAILROADS.

Structural Timber.

DEFINITIONS.

AXIS.—The line connecting the centers of successive cross-sections of a stick.

CORNER.—The line of intersection of the planes of two adjacent longitudinal surfaces.

CROSS-SECTION.—A section of a stick at right angles to the axis.

EDGE.—Either of the two narrower longitudinal surfaces of a stick.

FACE.—The surface of a stick which is exposed to view in the finished structure.

FULL LENGTH.—Long enough to "square" up to the length specified in the order.

GIRTH.—The perimeter of a cross-section.

HEARTWOOD.—The older and central part of a log, usually darker in color than sapwood. It appears in strong contrast to the sapwood in some species, while in others it is but slightly different in color.

OUT OF WIND.—Having the longitudinal surfaces plane.

SIDE.—Either of the two wider longitudinal surfaces of a stick.

SOLID.—Without cavities; free from loose heart, wind shakes, bad checks, splits or breaks, loose slivers and worm or insect holes.

SOUND.—Free from decay.

SPRINGWOOD.—The inner part of the annual ring formed in the earlier part of the season, not necessarily in the spring, and often containing vessels or pores.

SQUARE-CORNERED.—Free from wane.

STRAIGHT.—Having a straight line of an axis.

SUMMERWOOD.—The outer part of the annual ring formed later in the season, not necessarily in the summer, being usually dense in structure and without conspicuous pores.

TRUE.—Of uniform cross-section. Defects are caused by wavy or jagged sawing or consist of trapezoidal instead of rectangular cross-sections.

Names for Varieties of Structural Timber.

CEDAR covers White Cedars: Thuya occidentalis, Maine to Minnesota and northward; Chamæcyparis thyoides, Atlantic Coast from Maine to Mississippi; Chamæcyparis lawsoniana, along the coast line of Oregon; Libocedrus decurrens, Cascades and Sierra Nevada of Oregon and California. Red Cedars: Thuya gigantea, Washington to Northern California and eastward to Montana; Juniperus virginiana, throughout United States. Western Red Cedar: Thuja plicata.

---

[13] Adopted, Vol. 22, 1921, pp. 494, 1072.

CYPRESS (Taxodium distichum) covers bald cypress, black, white and red cypress, from swamp and overflow land along the coast and rivers of the Southern States.

DOUGLAS FIR.—The term "Douglas Fir" covers the timber known as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, Northwest and West Coast fir.

HEMLOCK covers Southern or Eastern hemlock; that is, hemlock from all states east of and including Minnesota.

IDAHO WHITE PINE covers the variety of white pine from Western Montana, Northern Idaho and Eastern Washington.

NORWAY PINE covers what is known also as "Red Pine" and Banksian (Pinus Banksiana).

OAK.—Under this heading three classes of timber are used: (a) White Oak, to include White Oak, Burr Oak and Post Oak; (b) Red Oak, to include Red Oak, Scarlet Oak, Black Oak and all bastard oaks; (c) Chestnut Oak, to include only Chestnut Oak.

REDWOOD includes the California wood usually known by that name.

SOUTHERN YELLOW PINE.—This term includes the species of yellow pine growing in the Southern States from Virginia to Texas, that is, the pines hitherto known as longleaf pine (Pinus palustris), shortleaf pine (Pinus echinata), loblolly pine (Pinus taeda), Cuban pine (Pinus heterophylla) and pond pine (Pinus serotina).

SPRUCE covers Eastern spruce; that is, the spruce timber coming from points east of and including Minnesota.

TAMARACK covers the timber known as "Tamarack," or "Eastern Tamarack," from states east of and including Minnesota.

WESTERN HEMLOCK covers hemlock from the Pacific Coast.

WESTERN LARCH covers the species of Larch or Tamarack from the Rocky Mountains and Pacific Coast regions.

WESTERN PINE covers the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

WESTERN OR SITKA SPRUCE covers spruce timber from the Pacific Coast.

WHITE PINE covers the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

Classification Terms.

LUMBER is the product of the saw and planing mill not further advanced in manufacture than by sawing, resawing and passing lengthwise through a standard planing machine, crosscutting to length, and end matching.

Lumber is classified as yard lumber, shop or factory lumber and structural timber. Different grading rules apply to each class of lumber.

Yard Lumber is lumber that is less than six inches in thickness and is intended for general building and construction purposes. The grading of yard lumber is based upon the use of the entire piece, except when a stated amount of waste to remove defects is provided in the classification of the material under consideration.

Shop or Factory lumber is intended to be cut up for use in further manufacture and is graded on the basis of the percentage of the area which will produce a limited number of cuttings of a given minimum size and quality.

Structural Timber is lumber that is six inches or over in thickness and width. The grading of structural timber is based upon the strength of the piece and the use of the entire piece.

Yard lumber is classified roughly as finishing and construction lumber. There is no sharp line between finishing and construction lumber. The medium grades may be used for either purpose.

Finishing is yard lumber of the higher grades in which appearance, perfection of the surface and finishing qualities are primarily the basis on which the grade is determined. The higher finishing grades are more suitable for "natural" or transparent finishes while the lower finishing grades are smooth and free from serious defects and are particularly adapted to the use of paint.

Construction Lumber is yard lumber which is graded primarily upon the basis of its strength as affected by defects, and its fitness for general construction purposes.

Strips are yard lumber less than two inches thick and under eight inches wide. Strips are usually manufactured into matched and patterned lumber.

Boards are yard lumber less than two inches thick and eight inches or over wide.

Planks are yard lumber two inches and under four inches thick and eight inches and over in width.

Scantlings are yard lumber two inches and under six inches thick and under eight inches wide.

Heavy Joists are yard lumber that is four inches and under six inches thick and eight inches and over wide.

Dimension includes all yard lumber except boards and strips; that is, yard lumber two inches and under six inches thick and of any width.

Manufactured lumber is classified as rough, surfaced and worked.

Rough lumber is undressed lumber left as it comes from the saw.

Surfaced lumber is lumber that is dressed by running through a planer. It may be surfaced on one side (SIS), two sides (S2S), one edge (S1E), two edges (S2E), or a combination of sides and edges (as S1S1E, S2S1E, or S1S2E).

WORKED lumber is lumber which has been run through a matching machine, sticker or moulder. Worked lumber may be matched, shiplapped or patterned. Patterned lumber is usually matched or shiplapped.

MATCHED lumber is lumber that is edge dressed and shaped to make a close tongue and groove joint at the edges or ends when laid edge to edge or end to end.

SHIPLAPPED lumber is lumber that is edge dressed to make a close rabbeted or lap joint when laid edge to edge.

PATTERNED lumber is worked lumber that is shaped to a patterned or moulded form.

Definitions of Defects and Blemishes.

The terms "Defect" and "Blemish" as applied to wood usually imply the idea of imperfections. These are not always detrimental.

DEFECT.—Any irregularity or want occurring in or on wood that may lower some of its strength value.

BLEMISH.—Any mark or formation of wood structure marring the appearance.

The presence of a defect or blemish may or may not be detrimental to the value of the material, depending upon the character of the defect or blemish and the use of the material.

Knots.

KNOT.—The hard mass of wood formed in a trunk of a tree at a branch with the grain distinct and separate from the grain of the trunk.

KNOTS shall be classified according to size, form and quality.

The average of the maximum and minimum diameters shall be used in measuring the size of knots unless otherwise stated.

In all grades of material all knots should be sound and tight unless otherwise specified.

PIN KNOT.—One not over ⅜ of an inch in diameter.

SMALL KNOT.—One between ⅜ and ¾ of an inch in diameter.

STANDARD KNOT.—One between ¾ and 1½ inches in diameter.

LARGE KNOT.—One over 1½ inches in diameter.

ROUND KNOT.—One whose maximum diameter is not over one and one-half times as great as its minimum diameter.

OVAL KNOT.—One having its maximum diameter one and one-half to three times as great as its minimum diameter.

SPIKE KNOT.—One sawed in a lengthwise direction whose maximum diameter is over three times as great as its minimum diameter.

SOUND KNOT.—One which is solid across its face, and is as hard as the wood surrounding it and shows no indications of decay.

UNSOUND OR ROTTEN KNOT.—One not as hard as the wood surrounding it or one in which decay has started.

TIGHT KNOT.—One so fixed by growth or position that it will firmly retain its place in the piece.

LOOSE KNOT.—One not held firmly in place by growth or position.

LIVE KNOT.—One whose growth rings are completely intergrown with those of the surrounding wood.

ENCASED KNOTS.—One whose growth rings are not intergrown and homogeneous with the growth rings of the surrounding wood. The encasement may be partial or complete.

WATERTIGHT KNOT.—One whose growth rings are completely intergrown with those of the surrounding wood on one face of the piece, and which is sound on that face.

PITH KNOT.—Sound knot except that it has a pith hole in the central growth ring. The hole rarely exceeds ¼ of an inch in diameter.

Holes.

HOLES in wood may extend partially or entirely through the piece. They are enumerated as knot, dog, picaroon, bird, insect (including pin, shot, spot, grub worms, etc.) metal and wooden rafting pin holes, through pitch pockets and the like.

When holes are permitted, the average of the maximum and minimum diameters at right angles to the direction of the hole shall be used in measuring the size, unless otherwise stated.

WOODEN RAFTING PINHOLES sometimes appear on river timber which has been rafted when holes have been bored in the solid wood for securing the timber, and a solid plug or pin driven in the hole, completely filling it. These defects must be treated and considered the same as Knot Defects. Ordinary Metal Rafting Pin, Cant Hook or Chain Dog-hole is not considered a defect.

GRUB WORM HOLES are usually from about ⅛-inch to $\frac{3}{16}$-inch in width, and vary in length from about 1 inch to 1½ inches and are caused by grubs working in the wood.

PIN WORM HOLES are very small holes caused by minute insects or worms. These holes are usually not over $\frac{1}{16}$-inch in diameter, the wood surrounding them is sound and does not show any evidence of the worm hole having any effect on the wood other than the opening.

SPOT WORM DEFECTS (also known as Flagworm Defects) are caused, like pin worm holes, by minute insects or worms working on the timber during the growth. The size of the hole is about the same as Pinworm holes, but the surrounding wood shows a colored spot as evidence of the blemish. This spot is usually sound and does not affect the strength of the piece.

Checks.

CHECK is a separation of the wood cells along a radial plane of the tree due to unequal shrinkage during seasoning.

Surface Check is a shallow check occurring on the surface of a piece.

End Check is one occurring on an end of a piece.

Through Check is one extending from one surface through the piece to the opposite surface or to an adjoining surface.

Heart Check is one starting at the pith and extending towards but not to the surface of a log and is not necessarily due to seasoning.

Star Check is the combination of several heart checks occurring together.

Honeycombing is checking occurring in the interior of a piece; often the checks are not visible on the surface. On a cross-section they usually appear as slits, or as open pockets whose width may appear very large in proportion to the radial length.

Ordinary season checks such as occur in lumber properly covered in yard, or season checks of equal size in kiln-dried lumber shall not be considered defects.

Shakes and Splits.

Shake is a cylindrical separation of the wood following in general the annual layers (rings) of growth. Thus any shake is a ring shake.

Round Shake is one completely encircling the pith.

Cup Shake is one that does not completely encircle the pith.

Through Shake is one extending from one surface through the piece to the opposite surface or to an adjoining surface.

Pitch Shake.—A clearly defined seam or opening between the grain of the wood and may be either filled or not with granulated pitch.

Split is a lengthwise separation of the wood due to tearing apart of the wood cells in rough handling, felling the tree or similar causes. It may run in any direction across the end of a piece.

Pith is the small soft core occurring in the center growth ring of a log. In some woods it is large enough to mar the surface of the piece on which it appears. The wood immediately surrounding the pith often contains small checks, shakes or numerous pin knots and is often discolored; any such combination of defects and blemishes is known as Heart Center.

Pockets.

Pitch Pocket.—A well defined opening between the annual layers of growth usually containing more or less pitch, either solid or liquid. Bark may also be present in the pocket. On an edge-grain surface they appear as narrow open seams, and on flat grain surface they vary in appearance from narrow open seams to oval cavities sometimes called "Scab Pitch Pockets." On either surface they are known as very small, small, medium or large, depending upon their size.

Very Small Pitch Pocket.—One not over ⅛ of an inch in width and not over 2 inches in length.

Small Pitch Pocket.—One whose maximum width may vary from ⅛ of an inch to ¼ of an inch provided a maximum limit of length of four inches decreases to two inches proportionately as the width increases.

Medium Pitch Pocket.—One whose maximum width may vary from ⅛ of an inch to ⅜ of an inch provided a maximum limit of length of nine inches decreases to three inches proportionately as the width increases.

Large Pitch Pocket.—One whose width or length exceeds the sizes stated as permissible for a medium pitch pocket.

Bark Pocket is a patch of bark partially or wholly enclosed in the wood. It may result from wood and bark forming over a place where the tree has been injured. As a defect it is measured in the same manner as a Pitch Pocket.

Streaks and Discolorations.

Pitch Streak.—A well defined and conspicuous accumulation of pitch in the wood cells. It is usually not considered an important blemish unless both springwood and summerwood appear saturated. They are known as small, medium or large depending upon their size with respect to the piece they are in.

Small Pitch Streak.—One whose area does not exceed the product of one-twelfth the width by one-sixth the length of the face on which it occurs.

Medium Pitch Streak.—One whose area does not exceed the product of one-sixth the width by one-third the length of the face on which it occurs.

Large Pitch Streak.—One whose area exceeds the product of one-sixth the width by one-third the length of the face on which it occurs.

Pith Fleck is a narrow streak, usually brownish, up to several inches in length on the face of a piece resulting from the larvæ of an insect having burrowed in the growing tissue or cells of the tree.

Bird Peck is a small hole or patch of distorted grain resulting from birds pecking through the growing cells in the tree. It usually resembles a carpet tack in shape with the point towards the bark and it is usually accompanied by a discoloration extending along the grain and usually to a smaller extent around the layers of growth. A section through the discoloration produced by the bird peck produces what is commonly known as "Mineral Streak."

Gum Spot or Streak is an accumulation of gum-like substance occurring as a small patch or streak in the piece. It may occur in conjunction with a bird peck or other injuries to the growing wood.

Discolorations on or in lumber are enumerated as weather, sticker, water or fungus (such as blue stain, etc.) stain, brown stain, kiln burn and similar color changes due to a combination of temperature, moisture, chemicals, etc. Discoloration may follow insect attack, bird peck, etc. Well defined discolorations are known as light, medium and heavy.

Light Discoloration is paler than the medium discoloration and occurs in approximately one-fourth of the stained stock.

Medium Discoloration is a shade most commonly found and which occurs in approximately one-half of the stained stock.

Heavy Discoloration is darker than the medium discoloration and occurs in approximately one-fourth of the stained stock.

Decay is disintegration of the wood substance due to the action of certain kinds of fungi. A few of the rot-producing fungi which start in the standing tree do not seem to seriously develop after the tree is cut into lumber.

Red Heart of the pines, spruces, Douglas fir and some other conifers, and peck of cypress and incense cedar are produced by fungi of this type. Decay may be classified as incipient and advanced decay.

Incipient Decay is the early stages of decay, usually detected by a discoloration of the wood which seems to be firm and solid.

Advanced Decay or rot is noticeable as a decided softening or breaking down of the wood.

Water Stain, or what are sometimes called scalded or burnt spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burnt spots where timber is improperly piled while green, are not considered defects, as they do not affect the strength of the piece.

"Sap"—Sapwood is the alburnum of the tree—the exterior part of the wood next to the bark. Sapwood is not considered a defect except as provided herein.

Sound Heart.—The term "Sound Heart" is used whenever that part of the piece which was originally the central part or core of the tree is sound and solid, not decayed.

Cross Grained Wood is that in which the wood cells or fibers do not run parallel with the axis or sides of a piece. It may be classified as spiral, diagonal, wavy, dip, curly and interlocked grain. The slope of the grain can be determined by observing the direction of surface checks, resin ducts, pores of the wood, annual layers of growth, etc. A drop of stained liquid such as ink tends to elongate in the direction of the grain when placed on a smooth surface of the piece.

Spiral Grained Wood is that in which the fibers take a more or less winding or spiral course, such as occurs in a twisted tree. It may be detected on the flat grain (plain sawed or tangential) surface.

Diagonal Grained Wood is that in which the fibers extend at an angle (i. e., diagonally) across a piece as a result of sawing at an angle across the annual layers of growth. It may appear on either the radial or tangential surface.

Wavy Grained Wood is that in which the fibers take the form of waves or undulations as indicated by the wavy surface of the split piece. It may appear on either the radial or tangential surface.

Dip Grained Wood is that which has one wave or undulation of the fibers such as occurs around knots, pitch pockets, etc.

Curly Grained Wood is that in which the fibers are distorted so that they take a curled direction as in "Birdseye Wood." These patches may vary up to several inches in diameter.

Interlocked Grain is wood that shows spiral grain in one direction for a number of years and then the slope of the grain in the succeeding annual layers of growth turns in a reverse direction around the tree, then later reverses back, etc.

Distortions and Crooks.

Cross Break is a separation of the wood cells across the grain. It may be due to tension resulting from unequal longitudinal shrinkage or mechanical stresses.

Compression Failure is a wrinkling or buckling of the wood cells extending in a more or less irregular plane across the grain. It is due to longitudinal crushing or compression.

Collapse is a caving in of the surface of a piece. It sometimes occurs in streaks giving the surface a corrugated appearance, and is often due to the flattening of the cells when drying wet wood at high temperatures.

Warping is any variation from a true or plane surface. It includes crook, bow, twist or any combination of these.

Crook is a deviation edgewise from a straight line drawn from end to end of a piece and is measured at the point of greatest departure from a straight line. It is known as slight, small, medium and large.

Unless otherwise specified, the different degrees of crook based on a piece four (4) inches wide and 16 feet long shall be as follows:

Slight Crook, a departure of one (1) inch.

Small Crook, a departure of 1½ inches.

Medium Crook, a departure of 2 inches.

Large Crook, a departure of over 2 inches..

For wider pieces it shall be ⅛-inch less for each additional 2 inches of width.

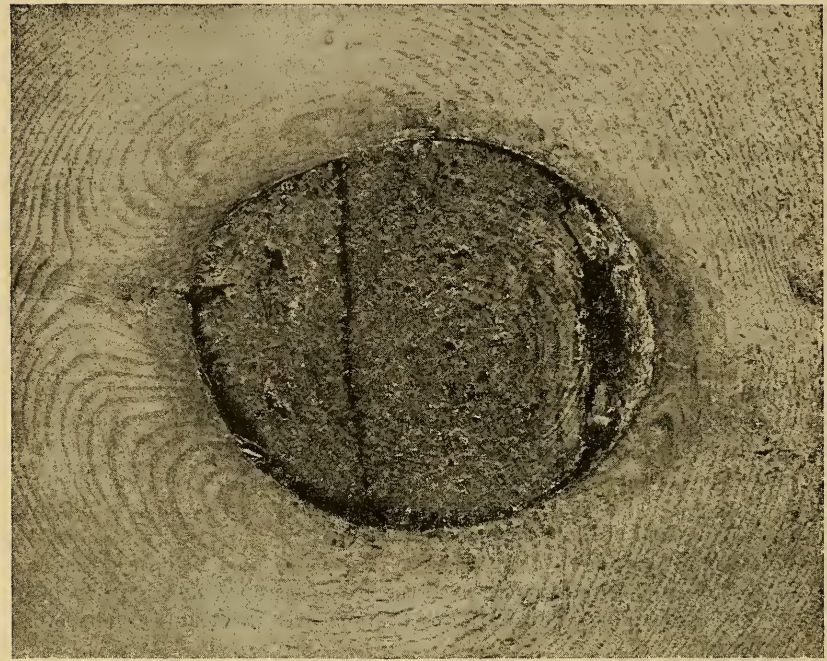
Shorter or longer pieces shall have the same limits for curvature.

Bow is a deviation flatwise from a straight line drawn from end to end of a piece measured at the point of greatest distance from a straight line.

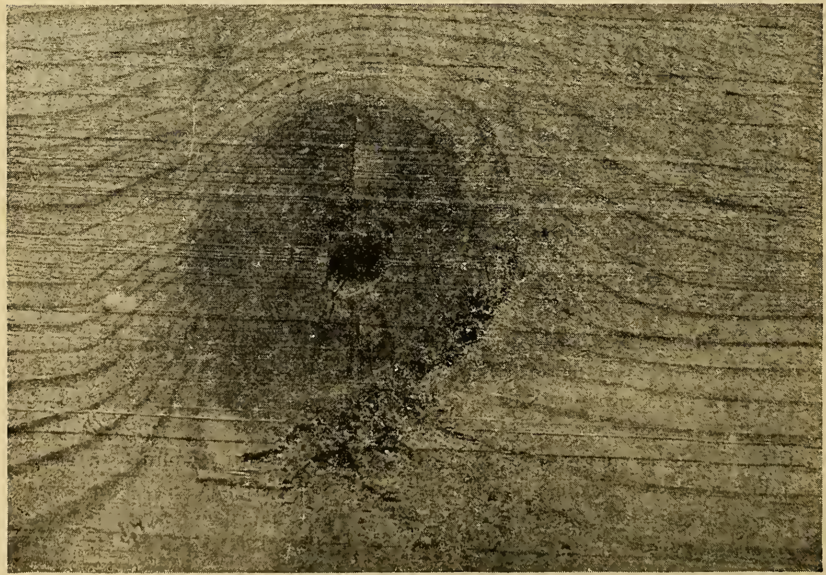
Cupping is the curvature of a piece across the grain or width of a piece.

Twisting is the turning or winding of the edges of a piece so that four corners of any face are no longer in the same plane (i. e., it is the twisting of an edge around the axis of the piece).

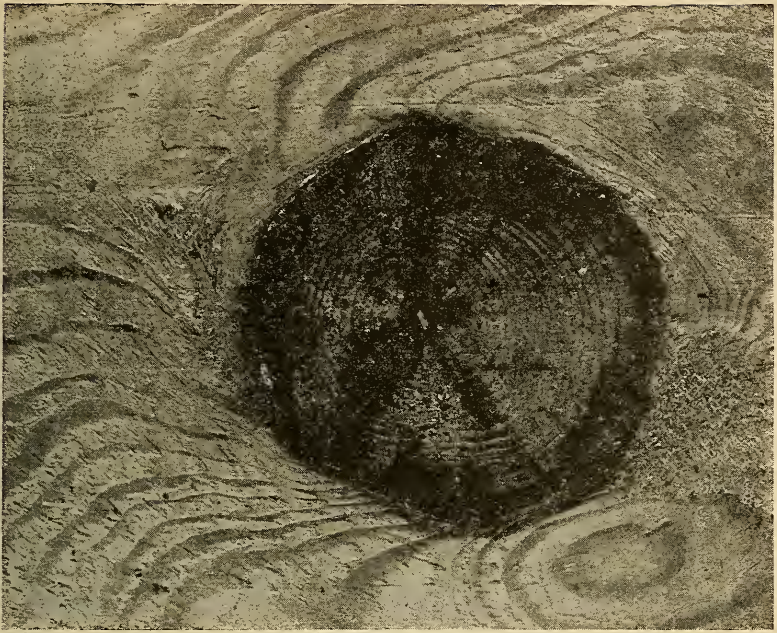
Wane is bark or the lack of wood, from any cause, on the edge of a piece.



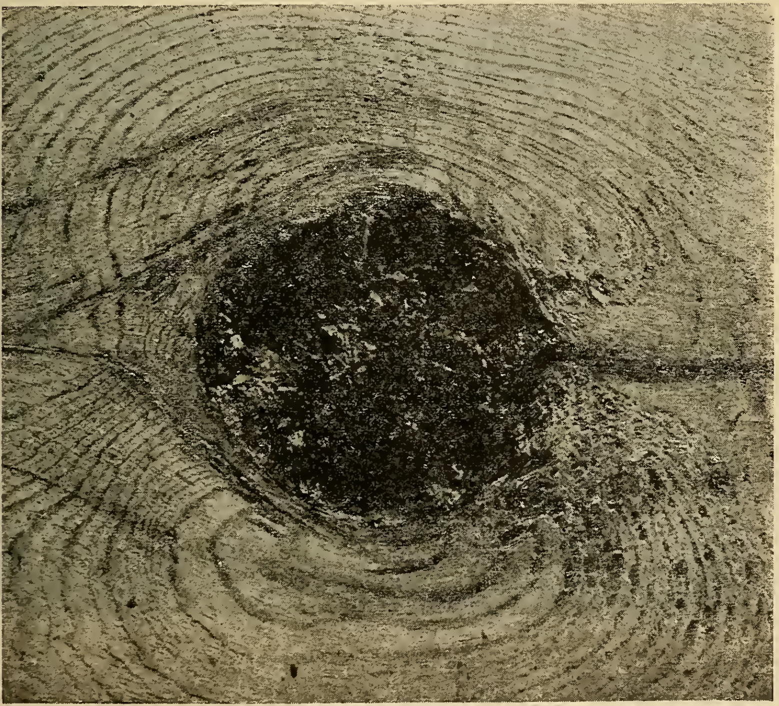
Loose Knot.



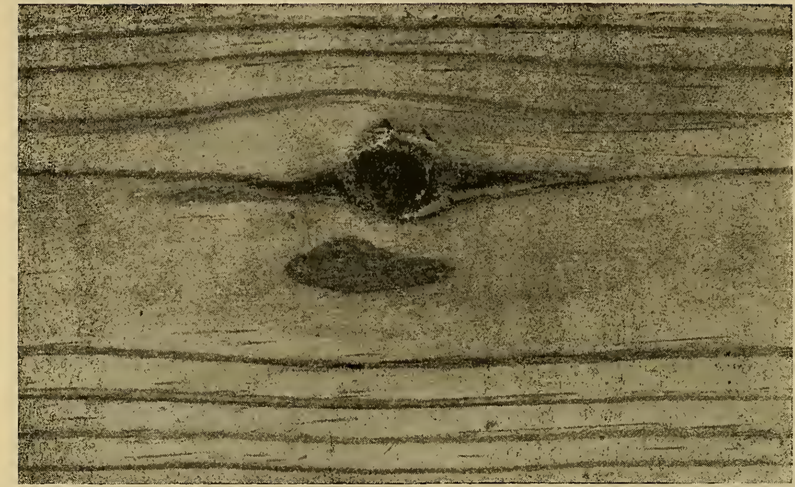
Pith Knot.



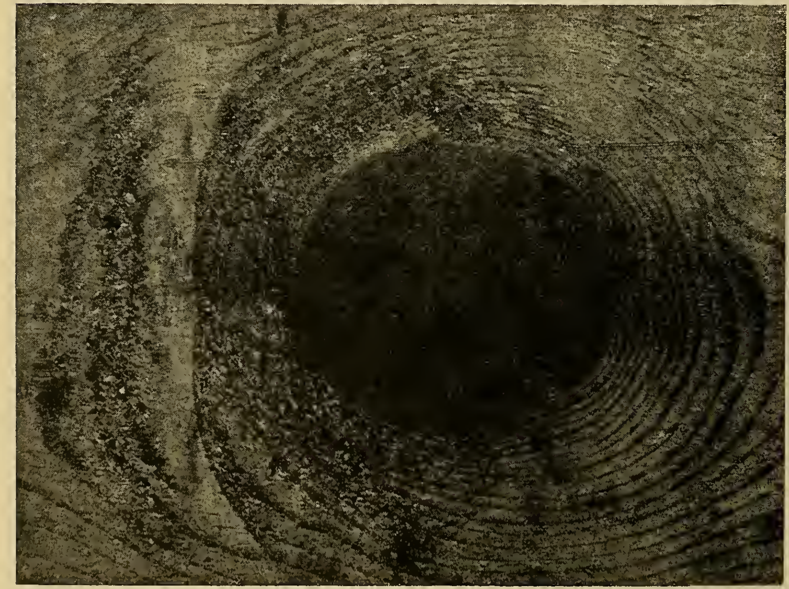
Encased Knot.



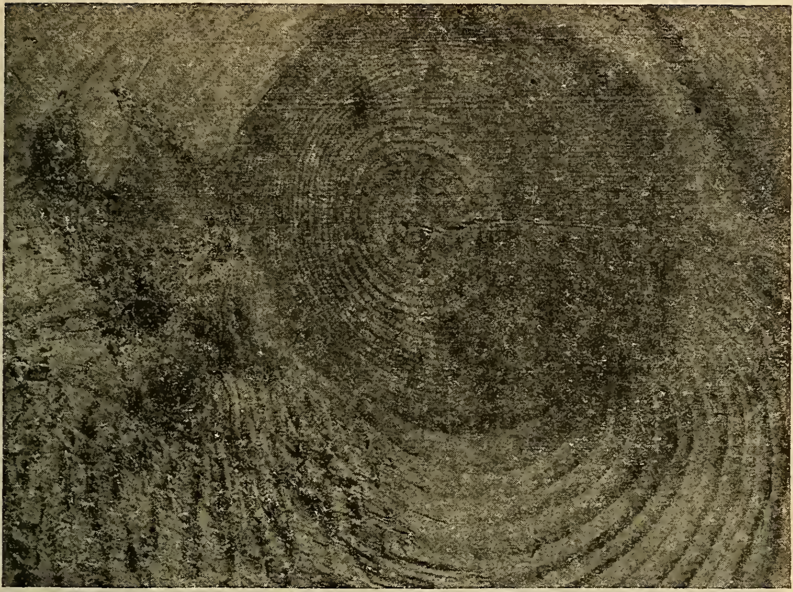
Rotten Knot.



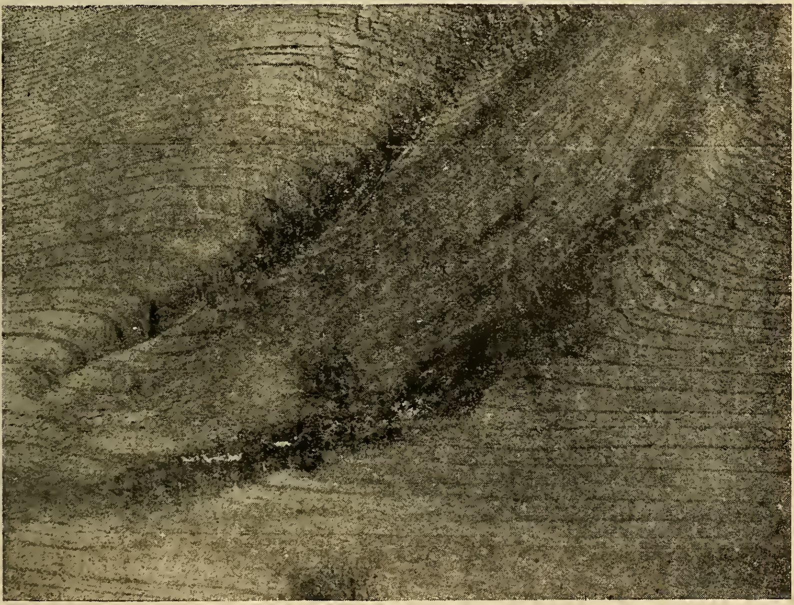
Pin Knot.



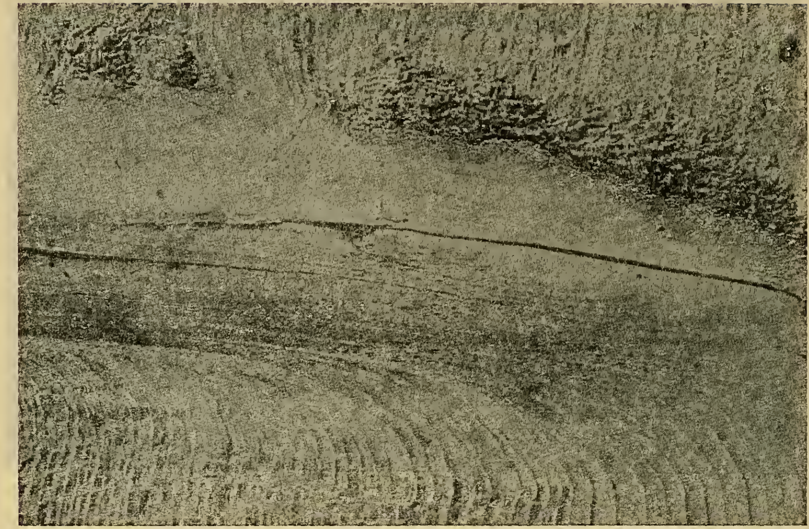
Standard Knot.



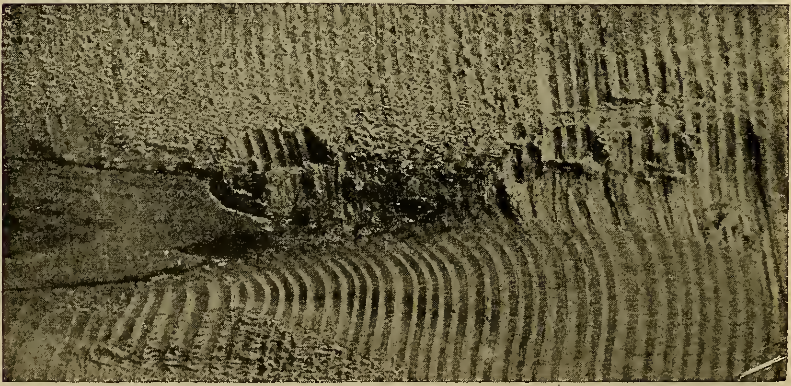
Large Knot.



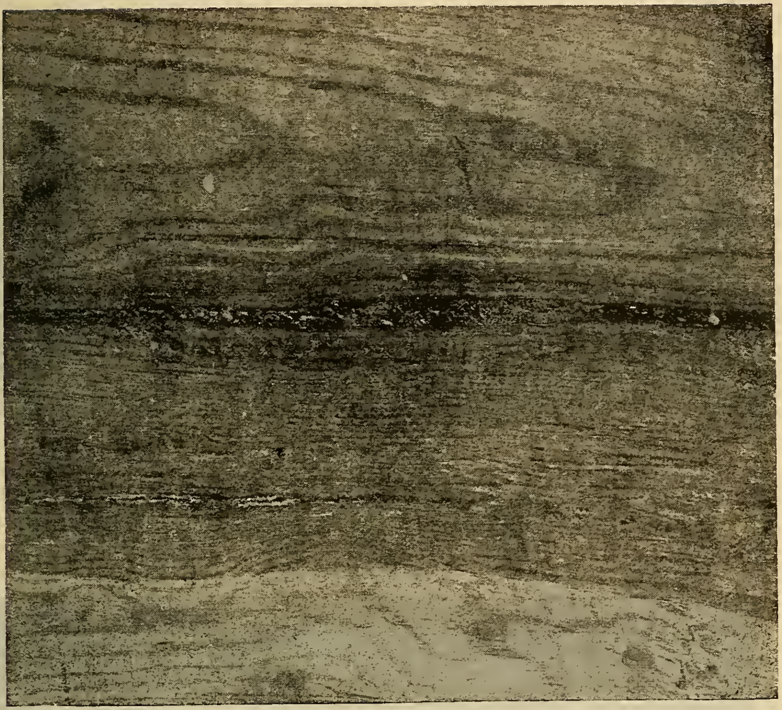
Spike Knot.



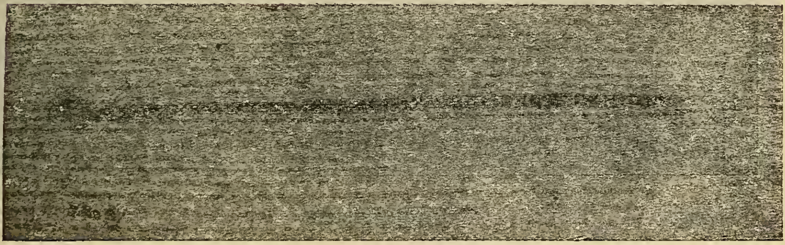
LARGE SPIKE KNOT.



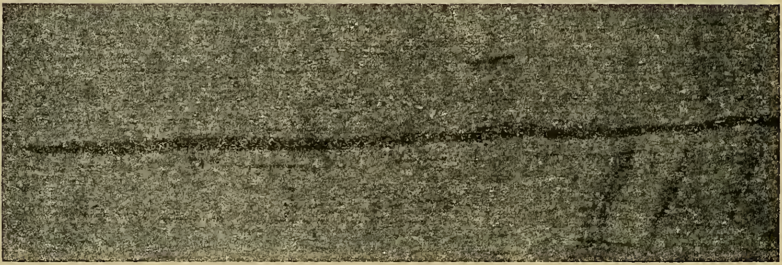
SMALL SPIKE KNOT.



Small Pitch Pocket.

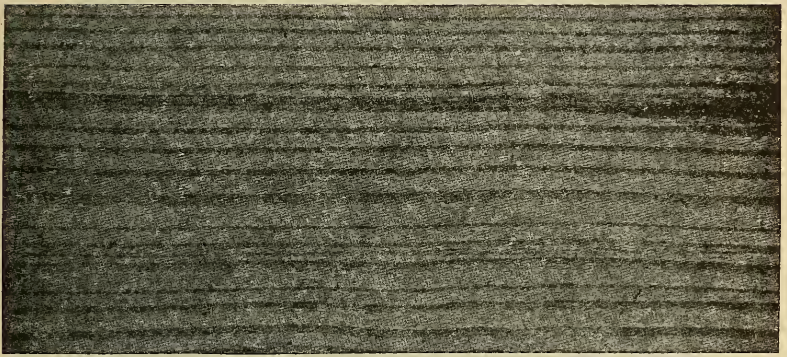


Closed Small Pitch Pocket.

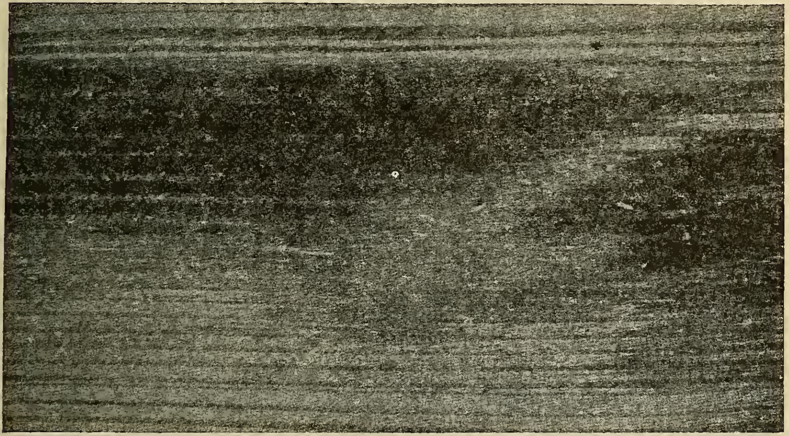


Large Open Pitch Pocket.

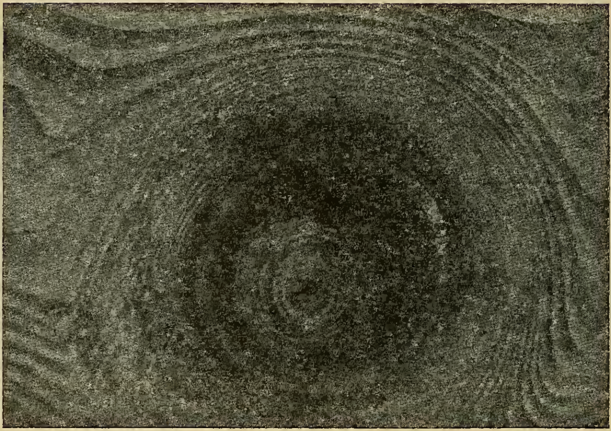
Pitch Streak.



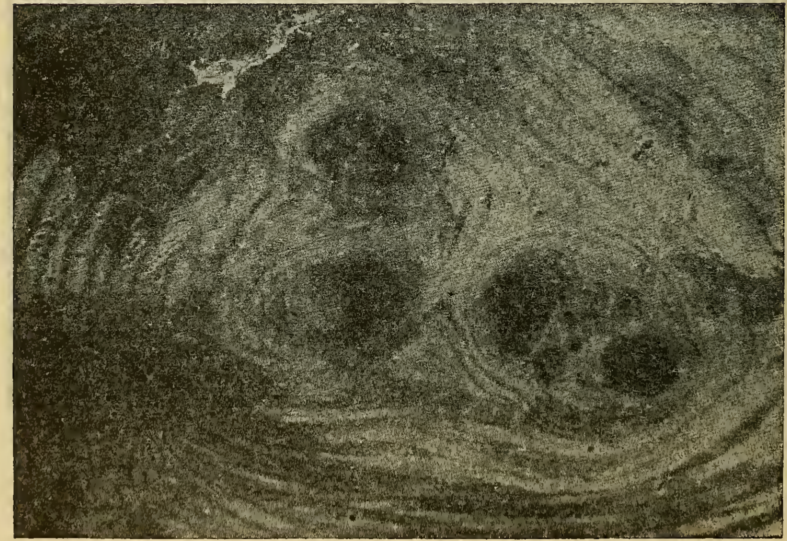
Small Pitch Streak.



Solid Pitch.

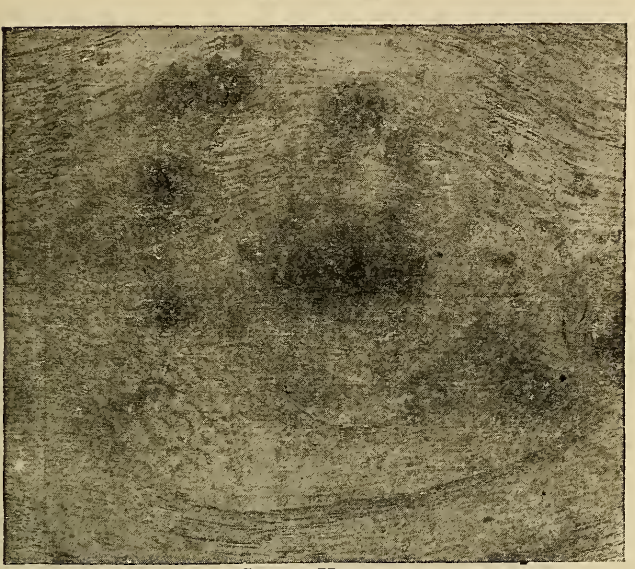


PITCH KNOT.

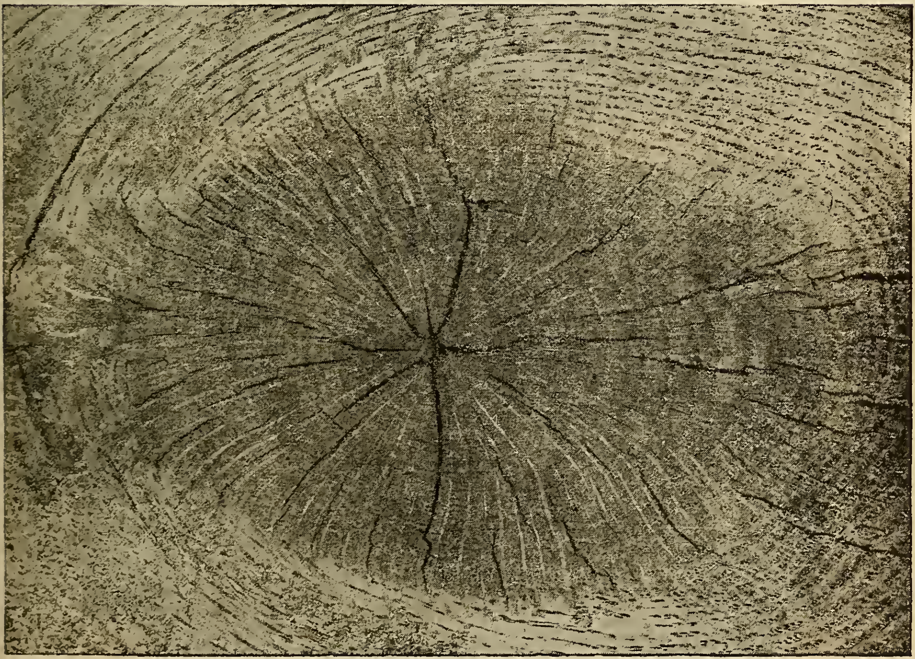


CLUSTER OF KNOTS.

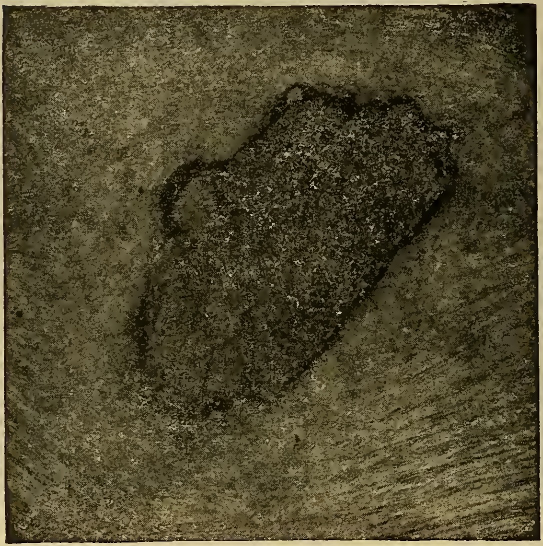
Oak Defects.



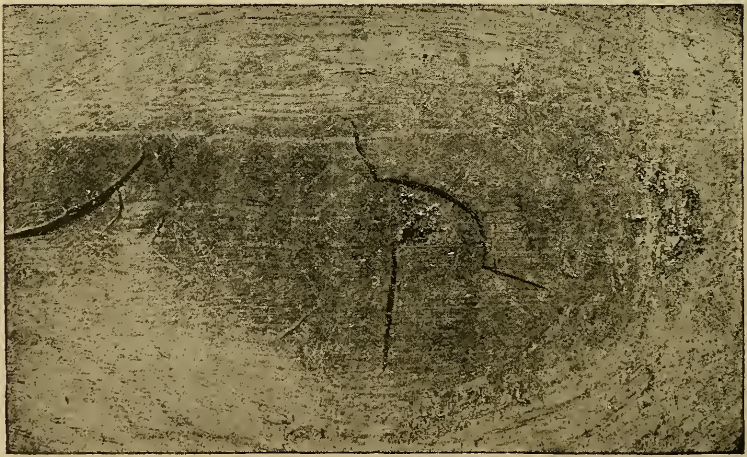
SOUND KNOT.



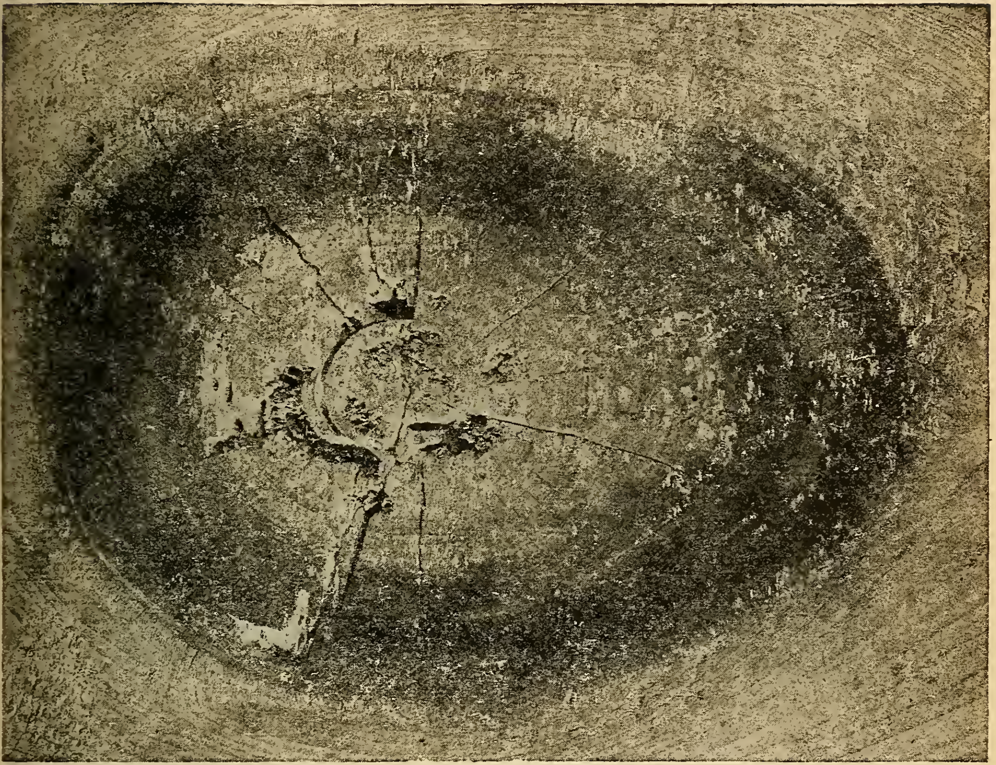
LARGE KNOT.



Loose Knot.

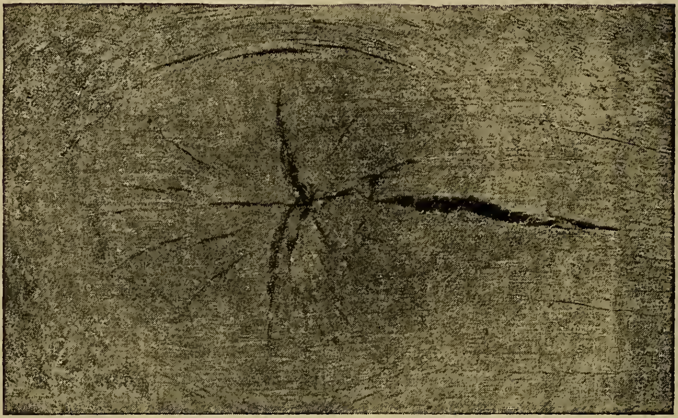


Pith Knot.

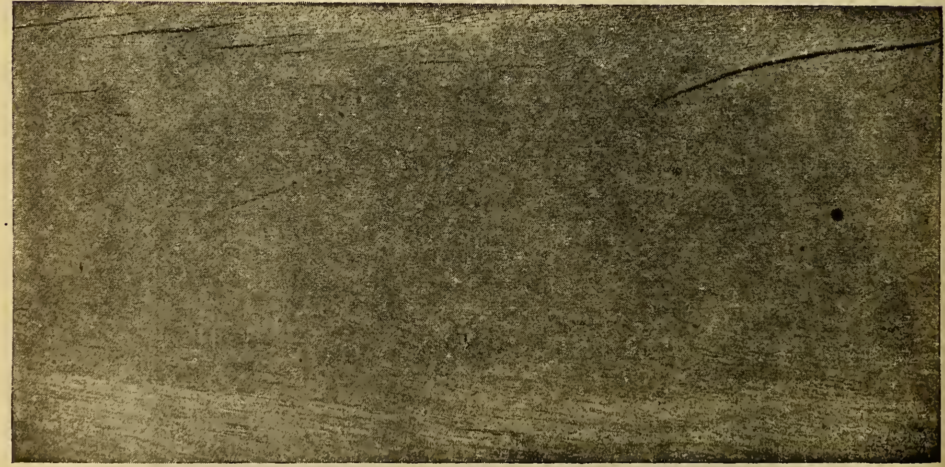


Rotten Knot.

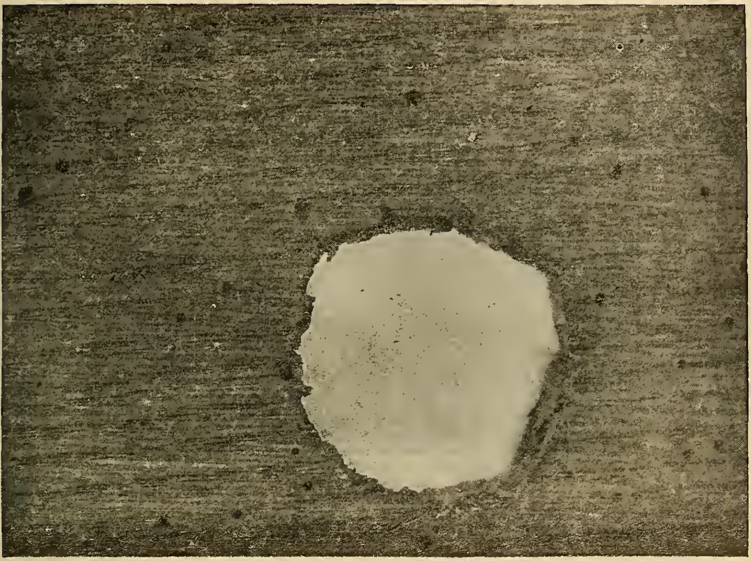
Pin Knot.



STANDARD KNOT.



BURL KNOT.

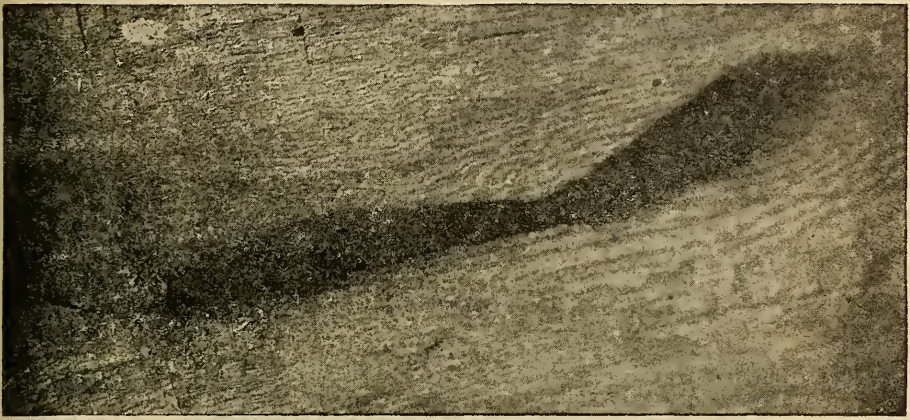


PIN WORM.

WOODEN RAFTING PIN HOLE.

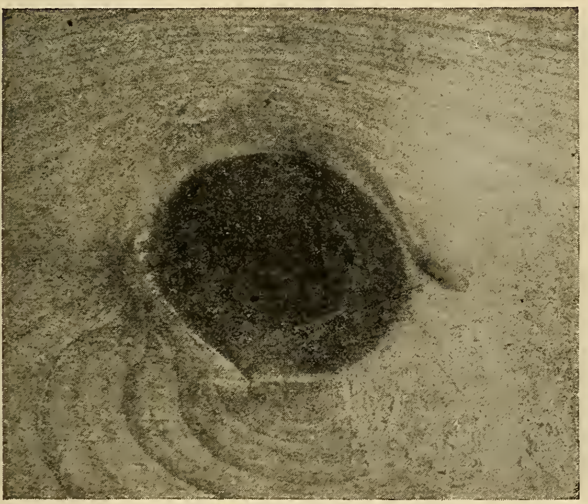
Spot Worm.

Metal Rafting Pin Hole.

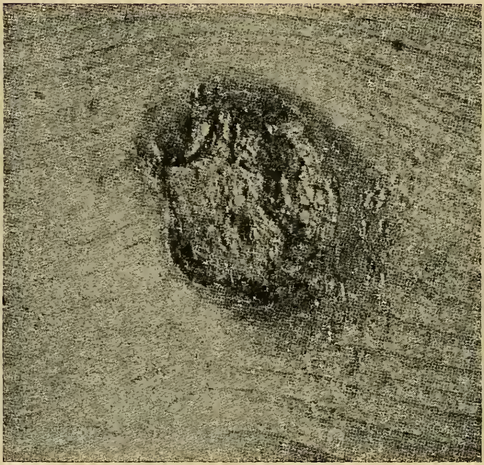


GRUB WORM HOLES.

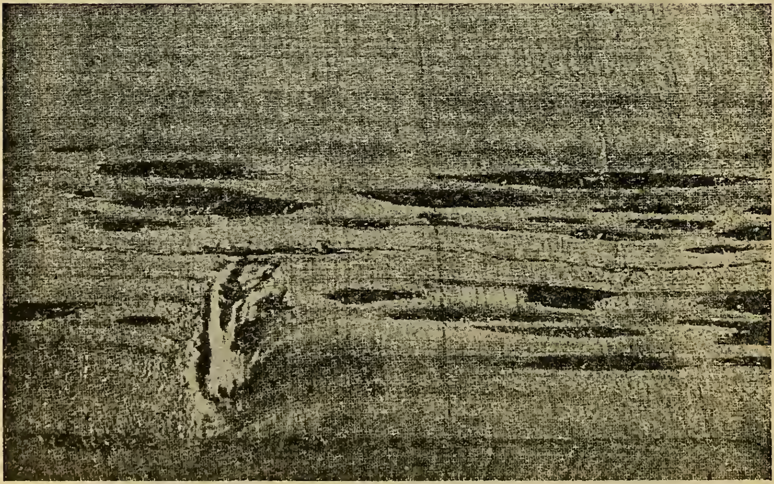
Cypress Defects.



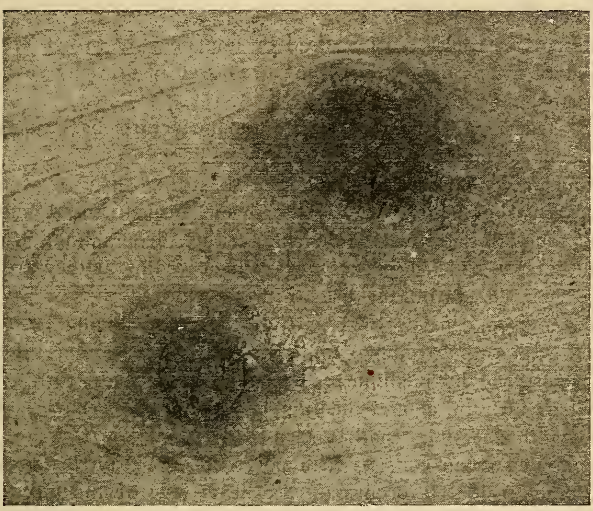
STANDARD SOUND KNOT.



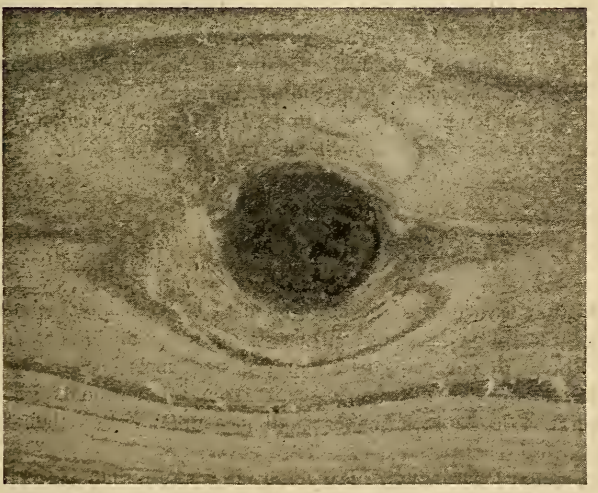
Rotten Knot.



Pecky Cypress.



Two Small Knots Equal to One Standard Knot.



Small Sound Knot.

SPECIFICATIONS.

Defects of Manufacture, Applicable to All Timber and Lumber.

1. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

2. In structural timber defects of manufacture have usually been omitted, being of minor significance.

3. Imperfect manufacture in dressed stock, such as torn grain, loosened grain, slight skips in dressing, wane, broken knots, mismatched, insufficient tongue or groove for flooring, ceiling, drop siding, etc., shall be considered defects, and will reduce the grade according as they are slight or serious in their effects on the use of the stock.

4. Torn grain consists of a part of the wood having been torn out in dressing. It occurs around knots and curly places and is of four distinct characters: slight, medium, heavy and deep. Slight torn grain shall not exceed $\frac{1}{32}$-inch in depth; medium $\frac{1}{16}$ and heavy ⅛-inch. Any torn grain heavier than ⅛-inch shall be termed deep.

5. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece and is a serious defect, especially in flooring.

6. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of cut and, as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

7. Pieces of Flooring, Drop Siding or Partition with $\frac{3}{16}$-inch or more of tongue; and pieces of Ceiling with ⅛-inch or more of tongue; and pieces of Ship Lap with $\frac{5}{16}$-inch of lap will be admitted in any grade.

8. Pieces of Flooring, Drop Siding, Ceiling or Partition having not less than $\frac{1}{16}$-inch tongue will be admitted in No. 2 Common. Pieces of Ship Lap having less than $\frac{5}{16}$-inch and not less than ⅛-inch lap shall be admitted in No. 2 Common.

Standard Sizes.

1. In the absence of a special agreement between buyer and seller for each order, the following sizes shall be standard for all lumber and timber.

2. "Rough timbers sawed to standard size" means that they shall not vary over one-quarter (¼) inch scant from the nominal size specified. For instance, a 12x12 inch timber shall measure not less than 11¾x11¾ inches.

3. "Standard Dressing" means that not more than ¼-inch shall be allowed for dressing each surface. For instance, a 12x12-inch timber, after being dressed on four sides, shall measure 11½x11½ inches.

Dimension S1S1E.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
2	1⅝	4	3⅝
2½	2⅛	5	4⅝
3	2⅝	6	5⅝
4	3⅝	7	6⅝
5	4⅝	8	7½
...	...	9	8½
...	...	10	9½
...	...	12	11½
...	...	14	13½
...	...	16	15½

Standard lengths are multiples of two feet, 4 to 24 feet, inclusive, but lengths shorter than 10 feet shall not be included in miscellaneous or mixed shipments except by agreement.

Common Boards and Strips.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
1 R	15/16	4	3⅝
1 S 1 S	⅞	6	5⅝
1 S 2 S	13/16	8	7½
1¼	1 1/16	10	9½
1½	1 5/16	12	11½

Dressed Finishing Lumber S1S

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
⅜	5/16	4	3⅝
½	7/16	5	4⅝
⅝	9/16	6	5⅝
¾	11/16	7	6⅝
1	13/16	8	7½
1¼	1⅛	9	8½
1½	1⅜	10	9½
2	1¾	12	11½
2½	2⅛	14	13½
3	2⅝	16	15½

The standard lengths are multiples of one foot.

Flooring.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
⅜	...	...	....
½	...	...	....
⅝	...	...	....
			Tongue and Groove
¾	11/16	3	2⅜
1	13/16	4	3¼
1¼	1 1/16	5	4¼
1½	1 5/16	6	5¼
2	1⅝	6 Factory	5⅛
2½	2⅛	...	....
			Splined
3	2⅝	6	5½
3½	3⅛	7	6½
4	3⅝	8	7½
...	...	9	8½
...	...	10	9½
...	...	12	11½
			Shiplap
...	...	6	5
...	...	7	6
...	...	8	7
...	...	9	8
...	...	10	9
...	...	12	11

Standard lengths are multiples of one foot from 4 to 20 feet. Five per cent. of 8 or 9 foot lengths is allowed in mixed length shipments of "B and Better" and in addition five per cent. of 6 or 7 feet in C, D and No. 1 Common, and in addition five per cent. of four or five feet in No. 2 Common, No. 3 Common, 4 to 20 feet inclusive.

The above percentage of short lengths is customary, and in the interest ot conservation will be included, as far as practicable, in all shipments of mixed lengths.

Ceiling.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
⅜	5/16	3	2⅜
½	7/16	4	3¼
⅝	9/16	5	4¼
...	...	6	5¼
1	¾	7	6⅛

Standard lengths are multiples of one foot, from 4 to 20 feet.

Five per cent. of 8 or 9 feet is allowed in mixed length shipments of "B and Better" Ceiling and in addition five per cent. of 6 or 7 feet in No. 1 Common, and in addition five per cent. of 4 or 5 feet in No. 2 Common.

The above percentage of short lengths is customary, and in the interest of conservation will be included, as far as practicable, in all shipments of mixed lengths.

Partition.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
3/8	5/16	3	2 3/8
1/2	7/16	4	3 1/4
5/8	9/16	5	4 1/4
3/4	11/16	6	5 1/4
1	3/4	7	6 1/8

Standard lengths are multiples of one foot.

Same percentage of short lengths is allowed as in ceiling.

Grooved Roofing.

Nominal thickness one (1) inch, actual thickness 13/16-inch.

Nominal Width Inches	*Actual Width Inches*
8	7 1/2
10	9 1/2
12	11 1/2

Roofers.

Roofers shall be made of No. 2 boards, 13/16-inch machine run, center matched and of nominal widths 6 or 8 inches as specified.

Fencing.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
1	13/16	3	2 5/8
1 1/4	1 1/16	4	3 5/8
1 1/2	1 5/16	5	4 5/8
...	...	6	5 5/8

Drop Siding, D&M.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
⅝	9/16	3	2¼
¾	11/16	4	3¼
1	¾	5	4¼
1¼	...	6	5¼
1½	...	...	...

Drop Siding, Worked Shiplap and Rustic.

Nominal thickness one (1) inch, actual thickness three-fourths (¾) inch.

Nominal Width Inches	*Actual Width Inches*
6	5⅛
8	7⅛
10	9⅛

Standard Lengths are multiples of 2 feet from 4 to 20 feet.

Five per cent. of 8 or 9 feet is allowed in mixed length shipments of "B and Better Drop Siding," and in addition five per cent. of 6 or 7 feet in "No. 1 Common" and in addition five per cent. of 4 or 5 feet in No. 2 Common.

The above percentage of short lengths is customary and in the interest of conservation will be included, so far as practicable, in all shipments of mixed lengths.

Shiplap.

Nominal thickness one (1) inch, actual thickness three-fourths (¾) inch, ⅜-inch lap.

Nominal Width Inches	*Actual Width Inches*
4	3⅛
6	5⅛
8	7⅛
10	9⅛
12	11⅛

Bevel Siding.

Nominal Thickness Inches	*Actual Thickness Inches*	*Nominal Width Inches*	*Actual Width Inches*
½ ¼ E	7/16 and 3/16	4	3½
....	....	5	4½
....	....	6	5½
⅝ ¼ E	9/16 and 3/16	...	...
¾ ¼ E	....	8	7¼
....	....	10	9¼
....	....	12	11¼

Standard lengths are multiples of one foot, from 4 to 20 feet. Five per cent. of 8 or 9 feet is allowed in mixed shipments of "B and Better," Bevel Siding, and in addition five per cent. of 6 or 7 feet in "No. 1 Common" and in addition, five per cent. of 4 or 5 feet in "No. 2 Common."

The above percentage of short lengths is customary, and in the interest of conservation will be included, so far as practicable, in all shipments of mixed lengths.

General Instructions on Grading Timber and Lumber.

1. No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The combinations and evaluations of defects are numerous and the interpretation of classification in grading lumber must be left to practical common sense. The general features of these classes are given by the following description of grades.

2. All lumber is graded with special reference to its suitability for the use intended.

3. With this in view each piece is considered and its grade determined by its general character, including the sum of all its defects.

4. Inspection of lumber is not an exact science and a reasonable variation of opinion between inspectors should be recognized; therefore, a variation of not more than 5 per cent. upon reinspection should not disturb the original inspection.

5. The enumerated defects herein described in any grade are intended to be descriptive of the coarsest piece such grades may contain.

6. In construing and applying these rules, the defects allowed are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

7. In case of a piece of lumber which lies so close to the boundary line between two grades that there is doubt as to which grade it belongs in, it shall be given the lower grade.

8. A shipment of any grade must consist of a fair average of that grade and shall not include an unfair proportion of the better or poorer pieces that would pass in that grade. A shipment of mixed widths shall contain a fair assortment of each width. A shipment of mixed lengths shall contain a fair assortment of each length.

9. Defects in lumber are to be considered in connection with the size of the piece, and for this reason wider and longer pieces will carry more defects than smaller pieces in the same grade. Defects in flooring, ceiling, partition, casing and base, drop siding and rustic are based on a piece 4 inches wide and 12 feet long, except where otherwise specified.

10. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or condition will prohibit a reinspection for the adjustment of claims, except with the consent of all parties interested.

11. What is known as "Yard Lumber," such as Dimension, Common Boards and Finish, etc., is graded from the face side, which is the best

side, except that lumber which is dressed one side only is graded from the dressed side.

12. Factory lumber, which is used for the manufacture of doors, sash, etc., and must show both sides, is always graded from the poorer side. The grade is determined by the quantity of suitable cuttings obtainable in each piece.

13. All dressed lumber shall be measured and sold at the full size of rough material used in its manufacture.

14. All lumber one inch or less in thickness shall be counted as one inch thick.

15. The term "Vertical Grain" is here used as synonymous with edge grain, rift sawed or quarter sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

Structural Grades for Bridge and Trestle Timbers.

Southern Yellow Pine and Douglas Fir Specifications.

Density Requirements.

Shall contain only Southern Yellow Pine or Douglas Fir timbers graded in two grades by the following density rules:

Density Rule for Southern Yellow Pine.

1. Dense Southern Yellow Pine shall show on either one end or the other an average of at least six annual rings per inch or eighteen rings in three inches as measured over the third, fourth and fifth inches of a radial line from the pith, and at least one-third (1/3) summerwood for girders not exceeding 20 inches in height, and for columns 16 inches square or less. For larger timbers the inspection shall be made over the central three inches on the longest radial line from the pith to the corner of the piece. Wide ringed material excluded by the above will be accepted, provided the amount of summerwood, as above measured, shall be at least 50 per cent.

2. The contrast in color between summerwood and springwood shall be sharp, and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood.

3. In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches of an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch (on the piece) nearest to the pith in timbers three inches or less in thickness.

4. In dimension material containing the pith but not a five-inch radial line, which is less than two by eight inches in section or less than eight inches in width, that does not show over sixteen square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material which does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

5. The radial line chosen shall be representative. In case of a disagreement between purchaser and seller as to what is a representative radial line, the average summerwood and number of rings shall be the average of the two radial lines chosen.

Density Rule for Douglas Fir.

1. Dense Douglas Fir shall show, on either one end or the other, an average of at least six annual rings per inch and at least one-third summerwood measured over three inches on a line located as described hereinafter. Coarse-grained material excluded by this rule shall be acceptable provided the amount of summerwood measured as described shall be at least one-half. Material in which the proportion of summerwood is not clearly discernible shall not be accepted.

2. Any timber whose least dimension is less than five inches shall not show the pith (heart) on the inspection end; pieces whose least dimension is five inches or more may contain the pith.

3. When the least dimension is five inches or more, the pith being present, the line over which the rate of growth and per cent. of summerwood measurements shall be made shall run from the pith to the corner farthest from the pith. To find the beginning of the three-inch line, measure a distance of one-half the least dimension of the piece, less two inches, from the pith. This distance may be expressed as follows:

$$a = \tfrac{1}{2} d - 2,$$

where a = distance in inches from pith to beginning of three-inch line.
d = least dimension of piece in inches.

4. When the rings are very irregular it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the three-inch line must not be changed.

5. For all pieces where the pith is not present the center of the three-inch line shall be at the center of the end of the piece, and the direction of the three-inch line shall be at right angles to the annual rings.

6. If a radial line of 3 inches cannot be obtained, the measurement shall be made over the entire radial line that is available.

General Requirements.

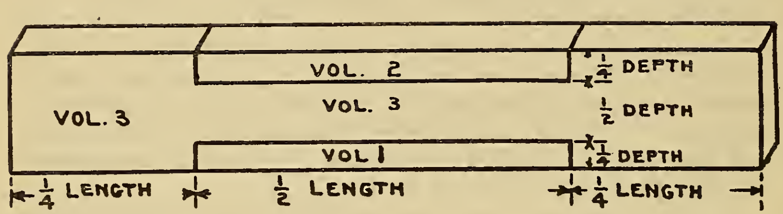
1. Shall consist of lumber well manufactured, square edges and sawed standard size.

2. When the timbers 4x4 inches and larger are ordered sized, they will be ½ inch less than nominal size, either S1S1E or S4S, unless otherwise specified.

3. Structural timbers shall be sound and free from rotten or unsound knots, knots in clusters, decay, round or ring shakes occupying more than one-fourth (¼) the least dimension on either end of a timber (a round or ring shake shall be measured on its vertical projection), injurious diagonal grain or other defects that will materially impair its strength. Shakes shall not show on any face of the timber.

4. Knots limited in size and position as hereinafter provided will be permitted if so fixed by growth or position that they will retain their place in the piece as at time of manufacture.

5. For the limitation of knots in beams in size and location, a beam shall be considered as divided into three volumes as shown below:



Measurement of Knots.

1. In beams, the diameter of a knot on the narrow or horizontal face shall be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

2. In columns, the mean or average dimension of a knot on any face shall be taken as its diameter.

3. Beams shall not have diagonal or spiral grain in Volumes 1 and 2 with slope greater than 1 in 20; in posts the angle shall not be greater than 1 in 15.

4. Posts and beams have different restrictions as to knots and angle of grain and must be listed accordingly in bills of material.

No. 1 Structural.

1. No. 1 Structural timbers shall be of Dense Southern Yellow Pine or Dense Douglas Fir, and shall meet the General Requirements for Structural Grades.

2. This grade shall not have tight pitch pockets over six (6) inches long or over ⅜ inch wide or wane exceeding one (1) inch on one corner or over one-sixth (1/6) the length of the piece.

3. Loose knots larger than one-half (½) inch shall not be permitted.

Beams, Stringers, Girders and Deep Joists.

1. Beams, Stringers, Girders and Deep Joists shall show not less than 85 per cent. of heart on each side of the four sides measured across the sides anywhere in the length of the piece.

2. Beams, Stringers, Girders and Deep Joists shall not have knots in Volumes 1 and 2 larger in diameter than one-fourth (¼) the width of the face of the beam in which they occur, up to and including six (6) inches, nor larger than one and one-half (1½) inches in a face over six (6) inches. Knots within the center half of the length of a beam shall not exceed in the aggregate the width of the surface of the beam in which they occur.

3. Beams shall not have knots in Volume 3 larger in diameter than one-fourth the width of the face in which they occur, with a maximum for any one knot of 3 inches in diameter.

4. When beams are of two spans length and so marked in bill of materials, Volumes 1 and 2 on inspection shall be considered as extending between points located one-eighth (⅛) the length of the beam from each end.

5. The inspector shall place his stamp on the edge of the beam or stringer to be placed up in service.

Caps and Sills.

1. Caps and Sills shall show 85 per cent. of heart on each of the four sides, measured across the surface anywhere in the length of the piece.

2. Caps and Sills shall be free from knots larger than one-fourth (¼) the width of the surface in which they occur with maximum for any one knot of 3 inches in diameter. Knots shall not be in groups.

Posts.

1. Posts shall show not less than 85 per cent. of heart on each of the four sides, measured across the surface anywhere in the length of the piece.

2. Posts shall not have knots larger than one-fourth (¼) the least dimension of the posts nor larger than three inches. Knots shall not be in groups.

Longitudinal Struts or Girts.

1. Longitudinal Struts or Girts shall show all heart on one surface; the other surface and two sides shall show not less than 85 per cent. of heart, measured across the face or side anywhere in the length of the piece.

2. Longitudinal Struts or Girts shall be free from knots over two inches in diameter.

Longitudinal Cross Braces, Sash Braces and Sway Braces.

1. Longitudinal Cross Braces, Sash Braces and Sway Braces shall show not less than 85 per cent. heart on two faces.

2. Longitudinal Cross Braces, Sash Braces and Sway Braces shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 inches in diameter.

Ties and Guard Timbers.

1. Ties and Guard Timbers shall show one side all heart; the other side and two edges shall show not less than 75 per cent. heart, measured across the surface anywhere in the length of the piece.

2. Ties and Guard Timbers shall be free from any large knots or other defects which will materially injure their strength; and where surfaced the remaining rough face shall show all heart.

No. 2 Structural.

1. No. 2 Structural Timbers shall meet the General Requirements for Structural Grades, and shall include timbers not passing the No. 1 Grade because of having less density than is required or greater defects than are permitted.

2. This grade shall not have pitch pockets longer than twelve (12) inches or over ⅜ inch wide or wane exceeding two (2) inches on one corner or the equivalent on two or more corners of 10x10 timbers, with wane in proportion on small or large sizes.

Beams, Stringers, Girders and Deep Joists.

1. Beams, Stringers, Girders and Deep Joists shall not have knots in Volumes 1 and 2 larger than as follows:

2. If of Dense Southern Yellow Pine or Dense Douglas Fir, one-third (⅓) the width of the face of the beam in which they occur, up to and including nine (9) inches, nor larger than three (3) inches in a face over nine (9) inches.

3. If not of Dense Southern Yellow Pine or Dense Douglas Fir, one-fourth (¼) the width of the face of the beam in which they occur, up to and including six (6) inches, nor larger than one and one-half (1½) inches, in a face over six (6) inches.

4. Knots in the center half of the length of a beam shall not exceed in the aggregate twice the width of the surface of the beam in which they occur.

5. Beams shall not have knots in Volume 3 larger in diameter than one-third (⅓) the width of the face in which they occur.

6. Loose knots larger than one-half (½) the size of knots allowed above shall not be permitted; beams shall not have loose knots, in Volume 3, larger than one and one-half (1½) inches.

Caps and Sills.

Caps and Sills shall be free from knots larger than one-half (½) the width of the face in which they occur with a maximum for any one knot of three (3) inches in diameter. Knots shall not be in groups.

Posts.

Posts shall not have knots, if of Dense Southern Yellow Pine or Dense Douglas Fir, larger than one-third (⅓) of the least dimension of the post, nor larger than four inches; if not of Dense Southern Yellow Pine or Dense Douglas Fir, larger than one-fourth (¼) the least dimension of the post, nor larger than three (3) inches.

Longitudinal Struts or Girts.

Longitudinal Struts or Girts shall be free from knots over 2 inches in diameter.

Longitudinal Cross Braces, Sash Braces and Sway Braces.

Longitudinal Cross Braces, Sash Braces and Sway Braces shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 inches in diameter.

Specifications for Timber to be Treated.

1. Specifications for timber to be treated are the same as for untreated timber, except that no restriction is to be placed upon the amount of sap wood allowed in the timber which is to be treated.

2. Many varieties of timber can be used, if treated, that would not be satisfactory to use in the untreated state on account of being subject to rapid decay if they are not treated.

Commercial Timber and Lumber Grades.

TIMBER.

Selected Common.

1. Selected Common shall be sound, strong timber, well manufactured and free from defects that materially impair its strength. Must be suitable for high-class construction purposes, free from shake, splits, loose or rotten knots. Will allow sound and tight knots, if not in clusters and which in no case shall exceed in diameter one-sixth the width of the face in which such knots occur up to and including 12x12-inch; and further providing that such sound and tight knots in 14x14-inch and larger shall in no case exceed 2½ inches in diameter.

2. The select common grade also will allow tight pitch pockets, not over six inches in length, wane not to exceed one inch on one corner and not exceeding one-sixth the length of the piece.

3. White sap or a slight amount of sound stained sap on the back shall not be considered a defect in this grade.

NOTE.—Commercial Timber and Lumber Grades here given apply to Southern Yellow Pine, Douglas Fir, White Pine, Western Pine, Idaho White Pine, Norway Pine, Spruce, Tamarack and Redwood products.

No. 1 Common.

1. No. 1 Common Timber 6x10 inches and larger shall be sound stock well manufactured and free from defects that will materially weaken the piece. Occasional slight variation in sawing allowed, provided such variation will not reduce size of stick below standard for dressed lumber.

2. Ten by ten-inch timbers may have a 2-inch wane on one corner or the equivalent on two or more corners, checks and season checks not extending over one-eighth the length of the piece. Smaller and larger timbers may have wane in proportion. In addition will allow large sound and tight knots, which approximately should not be more than one-fourth the width in diameter of any one side in which they may appear, spike knots, stained sap one-third the width and slight streak of heart stain extending not more than one-fourth the length of the piece.

No. 2 Common.

No. 2 Common Timbers will admit large, loose or rotten knots; a 10x10-inch may have a 3-inch wane on one corner or the equivalent on two or more corners, larger and smaller sizes in proportion; shake or rot that does not impair its utility for temporary work.

DIMENSION PLANK, JOISTS, SCANTLING AND SMALL TIMBERS.

Selected Common.

1. Selected Common shall be sound, strong lumber well manufactured and free from defects that materially impair the strength. Must be suitable for high-class construction purposes and free from shake, loose or rotten knots.

2. Will allow occasional variation in sawing, sound and tight, small and standard knots and tight pitch pockets not over 6 inches in length.

3. Twelve inches and wider may contain, in addition to the above, a couple of large knots not to exceed 2 inches in diameter when well placed, a slight amount of sap admissible.

No. 1 Common.

1. No. 1 Common must be sound stock, well manufactured and suitable for all ordinary construction purposes without waste and must be sound and tight-knotted stock.

2. Will admit knots which in a 2x4 or 3x4 piece may be approximately 1½ inches; in a 2x6-inch or 3x6-inch piece, 2 inches; in a 2x8-inch or 3x8-inch or 2x10-inch or 3x10-inch piece, 2½ inches; and one-fourth the width of the piece in 12 inches and wider; spike knots that do not materially weaken the piece; wane not over one-fourth the thickness of the piece 1 inch wide on face up to 6 inches, and 1½ inches wide on face of 8 inches and wider, extending not more than one-third the length of the piece or a proportionate amount for a shorter distance on both edges; in any case one side and two edges should provide a good nailing surface and in no case shall wane extend over one-half the side of the piece.

3. Pith knots or small defective knots which do not weaken the piece more than the knots above allowed are admitted, solid pitch, pitch pockets, sap stain, a limited number of worm holes well scattered, limited torn grain, seasoning checks, splits in ends, not exceeding in length the width of the piece, firm red heart, heart shakes that do not go through.

4. May contain crook of 1½-inch in 2x4—16 feet, and ⅛ inch less in each additional 2 inches in width up to and including 2x12—16 feet. Length longer or shorter than 16 feet of No. 1 Common Dimension may contain crook in proportion to the above.

No. 2 Common.

1. This grade shall consist of lumber suitable for a cheaper class of construction than No. 1 Common.

2. Will admit large, coarse sound knots, which in a 2x4 and 3x4-inch piece should not be larger than 2½ inches in diameter; in 2x6 or 2x8 or 3x6 or 3x8-inch pieces, 3 inches, and in 2x10 or 3x10 or wider pieces one-third the width of the piece in diameter, spike knots, smaller, loose, hollow or rotten knots that do not weaken the piece more than the knots aforesaid, worm holes well scattered, large pitch pockets, rotten streaks, small amount of fine shake, split not to exceed one-quarter the length of the piece, heart and sap stains in any amount, decayed sap, wane if leaving a fair nailing surface.

3. May contain crook of 2 inches in 2x4—16 feet, and ⅛ inch less in each additional 2 inches in width up to and including 2x12—16 feet. Length shorter or longer than 16 feet may contain crook in proportion to the above.

4. Miscut 2-inch Common which does not fall below 1½ inches in thickness or ⅛ inch scant in width from standard size, shall be admitted in No. 2 Common, provided such pieces are in all other respects as good as No. 1 Common at point of miscut.

5. A very serious combination of above defects must not be permitted in any one piece.

No. 3 Common.

1. No. 3 Common will include all pieces falling below No. 2 Common which are sound enough to use for cheap building material by wasting 25 per cent. of each piece or one-third of number of pieces in any one item of a shipment but it must not be more than ½ inch scant of standard finished width nor ⅜ inch scant of standard finished thickness. This grade will admit a greater degree of all the imperfections allowed in No. 1 and No. 2 Common, but shall not admit useless culls.

Boards, Ship Lap and D & M.

Selected Common.

Selected Common shall be square edged, well manufactured. Will admit sound tight knots not over 1 inch in diameter in 4-inch and 6-inch, not over 1½ inches diameter in 8-inch, medium sized tight pitch pockets not over 6 inches in length, two pith knots, the equivalent of one split not to exceed in length the width of the piece, torn grain, pitch pockets, slight shake, sap stain, seasoning checks, firm red heart, small amount of slightly stained sap. These boards must be of a sound, strong character.

No. 1 Common.

1. No. 1 Common will admit any two of the following or their equivalent of combined defects:

2. Sound and tight knots approximately 1½ inches in diameter in 4 and 6-inch; 2 inches in diameter in 8 and 10-inch; 2½ inches in 12-inch and not over 3 inches in diameter in widths over 12 inches.

3. Pitch pockets, seasoning checks, one straight split not longer than the width of the piece, sap stain, slight streak of heart stain, pith knots, torn grain, slight shake, firm red heart, wane ½ inch deep on edge not exceed-

ing 1 inch in width on face and extending not over one-third the length of the piece, a limited number of pin worm holes well scattered.

4. These boards must be firm, sound and suitable for use in ordinary construction except finishing purposes without waste.

5. No. 1 Common Ship Lap or D & M or Barn Siding shall be graded by rules governing No. 1 Common Boards except as to wane which shall not be so deep as to extend into the tongue or one-half the thickness of the top lip on the groove in D & M, or over one-half the thickness of the lap in Ship Lap on the face side; pieces of Ship Lap with $\frac{5}{16}$ inch of lap will be admitted in any grade.

No. 2 Common.

1. No. 2 Common will admit large coarse knots not necessarily sound, approximately 2 inches in diameter in 4 and 6-inch stock; 2½ inches in 8 and 10-inch and one-third the width of the piece in 12-inch and wider, spike knots, solid heart or sap stain, solid pitch or pitch pockets, a limited number of well scattered worm holes, splits one-fourth the length of the piece. Small amount of fine shake, wane 2 inches wide if it does not extend into the opposite face, or through heart shakes over one-half the piece or through rotten streaks when firm, ½ inch wide over one-fourth the length of the piece or its equivalent of unsound red heart or combination of defects equivalent to the above but a serious combination of above defects in any one piece not permitted.

2. A knot hole 2 inches in diameter will be admitted provided the piece is otherwise as good as No. 1 Common.

3. Miscut 1-inch Common Boards which do not fall below ¾ inch in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

No. 3 Common.

No. 3 Common will admit of stock below the grade of No. 2 Common that is suitable for cheap sheathing. The general appearance is coarse. It will admit large coarse knots without restrictions as to size, loose knots, unsound knots, knot holes, pitch pockets, solid pitch, very wormy pieces, shake, heart or sap stain, decayed sap, decayed streaks, well scattered small rotten spots, split, blue sap, wane, but a serious combination of above defects in any one piece not permitted. It should cut 75 per cent. of lumber as sound as No. 2 Common.

No. 4 Common.

1. No. 4 Common shall include all pieces that fall below the grade of No. 3 Common, excluding such pieces as will not be held in place by nailing, after wasting one-fourth the length of the piece by cutting into two or three pieces.

2. The predominating defect characterizing this grade is red rot. Other defects are numerous large worm holes, several knot holes, or pieces that are extremely coarse knotted, wany, shaky or badly split, extremely cross-checked.

No. 5 Common.

No. 5 Common is the lowest grade and admits of all defects known in lumber, provided the piece is strong enough to hold together when carefully handled.

Thick Common Lumber.

Common lumber, 1¼ inches and thicker, shall be graded the same as 1-inch lumber.

Rough Stock for Finish.

1. Finish must be evenly manufactured and shall embrace all sizes from 1 to 2 inches inclusive in thickness by 3 inches and over in width.

2. One, 1¼ and 1½-inch finishing lumber unless otherwise ordered shall measure when dry not more than $\frac{1}{16}$ inch scant in thickness and 2-inch not more than ⅛ inch scant in thickness when seasoned.

3. Stock width shipments of "C" and "Better," either rough or dressed on one or two sides, shall be accepted as standard where not more than 20 per cent. of any shipment is ¼ inch scant on 8-inch widths and under; ⅜ inch scant on 9 or 10-inch; and ½ inch scant on 11 and 12-inch and wider when seasoned; pieces narrower than the above and pieces in excess of 20 per cent. of the shipment that are of the minimum measurement given, should be measured as of the next lower standard width and not reduced in grade.

4. Standard lengths are 8 to 20 feet; and in shipments of mixed lengths, 5 per cent. of 8 feet in grade of "C" and "Better," shall be admitted. The above percentage of short lengths is customary and in the interest of conservation will be included as far as practicable in all shipments of mixed lengths.

5. Wane and other defects that will dress out in working standard sizes are admissible.

6. Finishing lumber ordered rough if thicker than count thickness for dry or green stock, may be dressed to such count thickness, and when so dressed, shall be considered as rough.

7. Rough finish shall be graded on the best side, but the reverse side must not be more than one grade lower.

8. Subject to the foregoing provisions, Rough Finishing Lumber shall be graded according to the rules applying to Dressed Finishing Lumber.

9. When like grade on both faces is required, special contract must be made.

Dressed Finishing Lumber.

Selected Flat Grain.

1. Selected Flat Grain shall be finishing lumber free from all sap or defects on face and edges and shall be selected for beauty and character of grain.

2. "A" Finishing, inch, 1¼, 1½ and 2-inch dressed one or two sides up to and including 12 inches in width, must show one face practically clear of all defects, except that it may have such wane as would dress off if surfaced four sides; 13-inch and wider "A" Finishing will admit two small defects or their equivalent. "B" Finishing, inch, 1¼, 1½ and 2-inch dressed one or two sides, up to and including 10 inches in width in addition to the equivalent of one split in end which should not exceed in length the width of the piece, will admit any two of the following or their equivalent of combined defects: slightly torn grain, three pin knots, one standard knot, three small pitch pockets, one standard pitch pocket, one standard pitch streak, 5 per cent. of sap stain or firm red heart; wane not to exceed 1 inch in width, ¼ inch in depth and one-sixth the length of the piece, small seasoning checks.

3. Eleven-inch and wider "B" Finishing will admit three of the above defects or their equivalent, but sap stain or firm red heart shall not exceed 10 per cent.

4. "C" Finishing up to and including 10-inch in width will admit in addition to the equivalent of one split in end which should not exceed in length the width of the piece, any two of the following, or their equivalent of combined defects: 25 per cent. of sap stain, 25 per cent. firm red heart, two standard pitch streaks, medium torn grain in three places, slight shake, seasoning checks that do not show an opening through, two standard pitch pockets, six small pitch pockets, two standard knots, six pin knots, wane 1 inch in width, ½ inch in depth and one-third the length of the piece. Defective dressing or slight skips in dressing will also be allowed that do not prevent its use as finish without waste. Eleven-inch and 12-inch "C" Finishing will admit one additional defect or its equivalent. Pieces wider than 12 inches will admit two additional defects to those admitted in 10-inch or their equivalent, except sap stain which shall not be increased.

Selected Flat Grain.

Pieces otherwise as good as "B" will admit of twenty worm holes.

Special Finish.

In case both sides are desired, "A," "B" or "C" grade, or free from all defects, special contract must be made. Defective dressing or slight skips in dressing on the reverse side of Finishing are admissible.

Moulded Casing, Base, Window and Door Jambs.

1. Moulded Casing and Base shall be worked to ¾ inch thick as per established patterns.

2. Window and Door Jambs are to be dressed, rabbeted and plowed as ordered.

Grades A, B and C.

1. "A" Grade must be practically free from defects on the face side and well manufactured.

2. "B" Grade shall admit the same defects as are admissible in the same widths of "B" Finishing except wane.

3. "C" Grade shall admit the same defects as are admissible in the same widths of "C" Finishing except wane.

MOULDING.

1. "B and Better" Moulding. One-third of any item may contain any one of the following defects or its equivalent: One pin knot, small pitch pockets, pitch 1 inch wide, 6 inches long, three pin worm holes, slight defects in dressing.

2. Standard lengths; 8 feet and longer, and in shipments of mixed lengths 5 per cent. of 6 or 7 feet shall be admitted, even though the number of feet of each length be specifically stated.

DROP SIDING.

1. Defects named in Drop Siding are based upon a piece manufactured from 1x6—12 feet, and pieces larger or smaller than this will take a greater or lesser number of defects, proportioned to their size on this basis.

2. The amount of crook permissible in No. 1 Common and Better Drop Siding may be as follows:

3. Sixteen-foot lengths as a basis for 4-inch widths, 3-inch crook.

4. Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

5. Lengths longer or shorter than 16 feet may have a proportional amount of crook.

6. In all grades of Drop Siding wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece is admissible, providing the wane does not extend into the tongue.

"A" Drop Siding.

1. "A" Drop Siding must be practically free from defects on the face side and well manufactured.

2. Slight roughness in dressing admissible.

3. A piece 14 feet or longer may have one defect located 4 feet or more from the end that can be cut out by wasting not more than 1½ inches of the length, provided balance of piece be practically free from other defects.

"B" Drop Siding.

1. "B" Drop Siding will admit any two of the following defects: Medium torn grain, three pin knots, one standard knot, 15 per cent. sap stain, 15 per cent. firm red heart, small seasoning checks, six pin worm holes or any one of the above defects combined with either three small pitch pockets or one small pitch streak.

2. A piece that is otherwise as good as "B" grade may have a defect that can be cut out by wasting not more than 2½ inches in the length of the piece, providing the defect is 4 feet or more from the end.

No. 1 Drop Siding.

1. No. 1 Common Drop Siding will admit numerous small or several medium or one large pitch pocket, one standard pitch streak and in addition sound knots not over one-half the width of the piece in the rough, a couple of small knot holes, pin worm holes or a few well scattered grub worm holes, sap stain, firm red heart, slight shake, heavy torn grain, seasoning checks that do not show an opening through, defects in manufacturing that will lay without waste. A very serious combination of above defects not permissible in any one piece.

2. Pieces otherwise as good as "B" Drop Siding may have one defect (like a knot hole) that can be cut out by wasting 2½ inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

No. 2 Common Drop Siding.

No. 2 Common Drop Siding admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

Bevel Siding.

Bevel Siding shall be graded according to the rules for Drop Siding and will admit in addition slight imperfections on the thin edge, which will be covered by the lap when laid 2½ and 4½ inches to the weather.

Rustic Siding.

Rustic Siding shall be graded according to the rules for Drop Siding.

FLOORING.

Special.

1. Defects named in Flooring are based upon a piece manufactured from 1x4—12 feet long, and pieces larger or smaller than this will take a greater or lesser number of defects proportioned to their size on this basis, except that standard knots shall not exceed 1¼ inches in diameter in 3-inch flooring.

2. The amount of crook permissible in No. 1 Common and Better Flooring may be as follows:

3. Sixteen-foot lengths as a basis for 3-inch widths, 3½-inch crook.

4. Sixteen-foot lengths as a basis for 4-inch widths, 3 -inch crook.

5. Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

6. Lengths longer or shorter than 16 feet may have a proportionate amount of crook.

7. Standard Matched Flooring to be surfaced two sides with scored back.

8. Center Matched Flooring (S2S and C. M.) shall be required to come up to grade on one side only, and the defects admissible on the reverse side of standard match shall be allowed.

GRADES A, B, C, D, AND NO. 1 COMMON EDGE OR VERTICAL GRAIN.

GRADES A, B, C, D, NO. 1 COMMON, NO. 2 COMMON, NO. 3 COMMON OR NO. 3 SHEATING, FLAT GRAIN.

Grade "A" Edge Grain Flooring.

Admits no piece in which angle of the grain exceeds 45 degrees from vertical at any point. This grade shall be well milled on face, must have perfect edges and be practically free from all defects on the face side. Bright sap showing not more than one-third of face half the length of piece will be admitted.

Grade "B" Grain Flooring.

Admits no piece in which angle of the grain exceeds 45 degrees from vertical at any point. This grade will admit any two of the following or their equivalent of combined defects: Five per cent. sap stain, 15 per cent. firm red heart, three pin knots, one standard pitch streak, slight torn grain, small seasoning checks.

Grade "C" Edge or Vertical Grain Flooring.

1. Admits no piece in which angle of the grain exceeds 45 degrees from vertical at any point. This grade will admit any two of the following defects or their equivalent or combined defects. Fifteen per cent. sap stain, 25 per cent. firm red heart, six pin knots, two standard knots, small pitch pockets, two standard pitch pockets, two standard pitch streaks, twelve pin worm holes, slight shake that does not go through, seasoning checks that do not show an opening through, medium torn grain or other machine defects that will lay without waste.

2. A piece 12 feet or longer otherwise as good as "B" may have a defect that can be cut out and the piece laid with a loss of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end of the piece.

Grade "D" Edge or Vertical Grain Flooring.

1. Admits no piece in which angle of the grain exceeds 45 degrees from vertical at any point. This grade will admit the following defects or their equivalent of combined defects: Sap stain, firm red hearts, sound knots not over one-half the cross-section of the piece in the rough and any one point throughout its length, three pith knots, pitch, pitch pockets, a limited number of pin worm holes, well scattered, shake that does not show an opening through, loosened or heavy torn grain or other machine defects that lay without waste.

2. Pieces otherwise as good as "B" Flooring may have one defect (like a knot hole) that can be cut out by wasting 20 inches of the length of the piece, provided both pieces are 16 inches or over in length after cutting out such defects.

3. It is generally understood that this grade will admit such defects or combination of defects as will not impair its utility for cheap floors.

4. No. 1 Common Flooring is the combined grade of C and D Flooring and will admit all pieces that will not grade "B" and are better than No. 2 Common Flat Grain Flooring.

5. Flat Grain Flooring shall take the same inspection as Edge or Vertical Grain, except as to requirement of angle of the grain.

No. 2 Common Flooring.

1. Admits all pieces that will not grade as good as "D" Flooring that can be used for cheap floors without waste of more than one-fourth the length of any one piece.

2. Pieces of flooring having not less than $\frac{1}{16}$ inch tongue will be admitted in No. 2 Common.

No. 3 Common or No. 3 Sheathing.

Admits all pieces that cannot be used as No. 2 Common Flooring but are still available as cheap sheathing or lathing without waste of more than one-fourth the length of any one piece.

CEILING.

1. Defects in Ceiling are based upon a piece manufactured from 1x4—12 feet long and pieces larger or smaller than this will take a greater or lesser number of defects, proportionate to their size on this basis.

2. The amount of crook permissible in No. 1 Common and Better Ceiling may be as follows:

3. Sixteen-foot lengths as a basis for 3-inch widths, 3½-inch crook.

4. Sixteen-foot lengths as a basis for 4-inch widths, 3 -inch crook.

5. Sixteen-foot lengths as a basis for 6-inch widths, 2½-inch crook.

6. Lengths longer or shorter than 16 feet may have a proportionate amount of crook. In all grades of Ceiling wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece is admissible providing the wane does not extend into the tongue.

7. Ceiling may be specified either as Edge or Vertical Grain or Flat Grain. The inspection will be the same for either kind.

"A" Ceiling.

"A" Ceiling must be practically free from defects on the face side, well manufactured, will admit of slight roughness in dressing, through close pitch pockets, each not to exceed 2 inches in length, or one sound and tight smooth pin knot, or the equivalent of combined defects.

"B" Ceiling.

1. "B" Ceiling will admit of any two of the following defects or their equivalent of combined defects: Slight torn grain, three pin knots, two small or one standard knot, three small pitch pockets, any two of which may be open, one standard pitch pocket, one small pitch streak, small seasoning checks, 15 per cent. sap stain, 15 per cent. firm red heart, six pin worm holes.

2. A piece otherwise as good as No. 2 may have a defect that can be cut out and the piece laid with a waste of not more than 2½ inches in length, providing the defect is 4 feet or more from the end of the piece.

No. 1 Common Ceiling.

1. No. 1 Common Ceiling will admit the following defects or their equivalent of combined defects: Heavy torn grain, sound knots not over one-half the cross-section of the piece in the rough, pitch, pitch pockets, seasoning checks that do not show an opening through, a sap stain, firm red heart, slight shake, defects in manufacture that will lay without waste, a limited number of pin worm holes well scattered.

2. Pieces otherwise as good as "B" Ceiling may have one defect (like a knot hole) that can be cut by wasting 2½ inches of the length of the piece, providing both pieces are 16 inches or over in length after cutting out such defects.

No. 2 Common Ceiling.

1. No. 2 Common Ceiling admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

2. Pieces of Ceiling having not less than $\frac{1}{16}$ inch tongue, will be admitted in No. 2 Common.

Partition.

Grades "A," "B," No. 1 Common and No. 2 Common. Partition shall be graded according to Ceiling rules and must meet the requirements of the specified grades on the face side only, but the reverse side shall not be more than one grade lower, and shall not cause waste in No. 1 Common and Better.

Specifications for Construction Oak.

General Instructions.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large per cent. is above the grade described.

Definition of Oak for Construction Purposes.

1. The term "Construction Oak" means all such products of oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak."

2. Firsts are to be sound and free from heart shakes and checks, but may have other defects as follows:

Construction Oak.

Trestle and Bridge Timbers.—Mud Sills, Stringers, Caps, Posts, Bracing, Bridge Ties, Struts, Guard Rails, Girts, Sash and Sway Braces.

Docking and Platform Timbers.—Mud Sills, Posts, Bracing Caps, Stringers, Joists, Dock and Platform or Flooring Plank and Wales.

Platform or flooring plank can be either square-edged or matched.

Framing for Building.—Mud Sills, Posts, Girders, Framing Joists, etc.

Bridge and Crossing Plank.—Railroad Crossing Plank, Bridge Floor Planking.

Sheet Piles.—Same as Crossing Plank, except may contain an unlimited amount of heart.

Round Piling.

Stock Guards.

Track or Bumper Posts.

Standard Names for Construction Oak.

Unless specifically mentioned, the terms "White Oak" and "Red Oak" include the following:

"White Oak."	**"Red Oak."**
White Oak	Red Oak
Chestnut or Tanbark Oak	Pin Oak
Burr or Mossy Cup Oak	Black Oak
Rock Oak	Water Oak
Post or Iron Oak	Willow Oak
Overcup Oak	Spanish Oak
Live Oak	Turkey Oak
Basket or Cow Oak	Black Jack or Barn Oak
Swamp Post Oak	Shingle or Laurel Oak
Yellow or Chinquapin Oak	Scarlet Oak

The term "Mixed Oak" means any kind of oak.

Specifications for Structural Oak Timbers.

General Requirements.

(1) Except as noted, all Structural Timbers shall be White Oak, to be sound timber and sawed specified sizes, free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote, wane in amounts greater than allowed in these specifications.

Boxed Hearts.

(2) Boxed Hearts are permitted in pieces of 5 by 5 inches square and larger. The center of the heart should be boxed as near the center of the piece as practical, and not to exceed 30 per cent. of the pieces can have the center of the heart nearer than 1½ inches from any face; 20 per cent. may show one heart face, corner or edge, not to exceed 75 per cent. of the length of the piece.

Wane.

1. The term 20 per cent. of number of pieces or amount shipped refers to each item and size of each car shipped.

2. Pieces 5x5 to 8x8 inches square may show 1 inch wane, side measurement, on any two corners or edges, and this wane not to exceed more than 25 per cent. of the length of the piece singly, or 50 per cent. in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

3. Pieces over 8x8, including 12x12 inches square, may show 1½ inch wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent. of the length of the piece singly or 66⅔ per cent. in aggregate. In the absence of wane on all of the length of the piece as above described, not to exceed 20 per cent. of the number of pieces may have this defect.

4. Pieces over 12 by 12 inches square may show 1¾ inch side measurement, any two corners or edges, and this wane not to exceed more than 40 per cent. of the length of the piece singly, or 80 per cent. in aggregate, in the absence of wane on all corners, excepting one, the corner may contain wane 80 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

5. In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

6. Pieces 1 inch to 5 inches thick, not exceeding 8 inches wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent. of pieces 2 inches and thicker may show sound heart on one face; pieces under 2 inches thick must be free of heart. Pieces 8 inches and wider may contain wane as per paragraphs b and d.

7. Rough sizes of Structural Timber shall not vary more than ¼ inch from specified size. Dressed sizes shall be ½ inch less than nominal size after dressing.

Bridge, Dock, Crossing Plank.

1. Lengths, cut to order.
Widths, cut to order.
Thickness, cut to order.

2. Sizes cut to order, probably 2 inches, 3 inches and 4 inches thick, 6 inches, 8 inches, 10 inches and 12 inches wide, 12 feet, 14 feet and 16 feet long.

3. This product is intended to work full one good sound face, and this face side must be square edge. Sound knots, small pin and spot worm holes no defect on face side.

4. Must be free from rot and shake; practically square edges, admitting 1 inch of wane on each edge of reverse face, running two-thirds the length. Sound hearts on one side, rafting pin holes, knot holes or grub holes not exceeding 2 inches in diameter admitted.

Sheet Piles.

Same as Ties, except that it may contain sound heart in heart check.

Stock Guards.

To be governed by specifications for Construction Oak.

Track End or Bumping Posts.

To be governed by specifications for Structural Timbers.

Classification and Grading Rules for Cypress Lumber and Shingles.

General Instructions.

Cypress lumber shall be graded according to the following rules and specifications, bearing in mind that as no arbitrary set of rules and specifications can be maintained in every case each must be left to the common sense and best judgment of the inspector.

1. Lumber shall be manufactured and shipped in standard lengths and thickness.

2. Tank, 1st and 2d and worked partition shall be graded from the poorer side.

3. Select lumber, flooring, ceiling, bevel siding and finishing shall be graded from the better or finished side, but the reverse side should in no case be more than one grade lower.

4. All lumber shall be tallied surface or face measure, the tally counted up, and the one-quarter or one-half added to the total where the lumber is one and one-quarter or one and one-half inches thick, and 2 inches and thicker to be multiplied by the thickness.

5. In the measurement of all lumber, fractions exactly on the one-half foot are to be given alternately to the buyer and seller; the fractions below the one-half foot are to be dropped, and all fractions above one-half foot are to be counted to the next higher figure on the board rule.

6. In "line boards," pieces 14 feet and longer shall be given the advantage in grade; pieces 12 feet and shorter shall be reduced in grade.

7. Recognized defects in cypress are knots, knot holes, shakes, splits, wane, wormholes, stained sap and peck.

Standard Lengths.

1. Random standard length stock may be furnished in odd as well as even foot lengths, but there shall not be to exceed 20 per cent. of odd lengths in any one item.

2. Tank stock and No. 1 barn shall be 8 feet and longer.

3. 1st and 2d and select shall be 10 to 20 feet.

4. Finish flooring, ceiling partition, bevel and drop siding shall be 10 to 20 feet.

5. Moldings and battens of all sizes 6 to 20 feet, in both odd and even foot lengths, but not exceeding 10 per cent. of 6, 7, 8 and 9 foot lengths.

6. No. 2 barn, 6 feet and longer.

7. Cull or peck, 4 feet and longer.

Standard Finished Sizes of Cypress.

1. Lumber shipped in the rough (except 8/4 inch No. 1 and No. 2 "Dimension," which grades may be ¼ inch under or ¼ inch over the size specified, both in thickness and width) shall be of sufficient thickness to S2S to standard thickness, as follows:

2. 4/4 Lumber S1S or S2S shall be $\frac{13}{16}$ inch thick.

3. 5/4 Select, 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅛ inches thick.

4. 6/4 Select, 1st and 2d clear, selected common tank and tank lumber S1S or S2S, shall be 1⅜ inches thick.

5. 6/4 Peck, No. 1 and No. 2 barn and finishing lumber S1S or S2S shall be $1\frac{5}{16}$ inches thick.

6. 8/4 Lumber, except No. 1 and No. 2 barn dimension S1S or S2S, shall be 1¾ inches thick.

7. 8/4 No. 1 and No. 2 barn or dimension S1S or S2S, shall be 1⅝ inches thick.

8. 10/4 Lumber S1S or S2S, shall be 2¼ inches thick.

9. 12/4 Lumber S1S or S2S, shall be 2¾ inches thick.

10. All lumber S1E takes off ⅜ inch. S2E, ½ inch.

11. All flooring shall be S2S and CM.

12. 4/4 Flooring shall be $\frac{13}{16}$ inch by 2¼ inch, 3¼ inch, 4¼ inch, 5¼ inch face.

13. 5/4 Flooring shall be $1\frac{1}{16}$, 6/4 shall be $1\frac{5}{16}$, by same widths as 4/4.

14. 3/8 Ceiling shall be worked $\frac{5}{16}$ inch, S1S only.

15. 1/2 Ceiling shall be worked $\frac{7}{16}$ inch, S1S only.

16. 5/8 Ceiling shall be worked $\frac{9}{16}$ inch, S1S only.

17. 3/4 Ceiling shall be worked $\frac{11}{16}$ inch, S1S only.

18. Widths of ceiling to be same as flooring, unless otherwise specified. Ceiling up to ¾ inch face to have one bead on one edge and ceiling wider than 3¼ inch face to be beaded center and edge.

19. Partition to be finished the same as ceiling, but on both faces.

20. Drop siding shall be worked ¾ inch by 3¼ inch, 4½ inch, 5¼ inch, 7¼ inch, 9¼ inch face, S2S and CM or shiplapped.

21. Bevel siding or bevel cribbing shall be worked ½ inch less in width than the rough strip measure.

Tank Stock.

1. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

2. Shall be 5 inches and wider, 1½ inches to 4 inches thick and 8 feet and over in length. Pieces up to 7 inches shall be free from sap. Pieces 7 inches to 13 inches may have one inch of sound sap on one edge, not to exceed half the length and half the thickness of the piece. Pieces 14 inches and wider may have 1 inch of sound sap on both edges not to exceed half the length and half the thickness of the piece. In all widths sound knots that do not impair usefulness for tank purposes may be admitted.

First and Second Clear.

1. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the poorer side.

2. Shall be 8 inches and wider, 1 inch to 4 inches thick and 10 feet and over in length. Pieces 8 to 10 inches may have 1 inch of bright sap on each edge, or its equivalent on one or both edges, otherwise they must be clear. Pieces 10 inches and under 12 inches may have 1½ inches of bright sap on each edge or 3 inches on one edge, and may have one standard knot or its equivalent. Pieces 12 inches wide may have 2 inches of bright sap on each edge, or 4 inches on one edge and may have one standard knot; or, in lieu of sap, may have two standard knots or their equivalent. Pieces wider than 12 inches may admit of defects as specified above in proportion as width increases. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece. Pieces 12 inches and less in width, free from other defects, may have bright sap across one face at one end, but this sap shall not exceed in length one-tenth of the length of the piece. In pieces 13 inches and wider bright sap is not a defect.

Selects.

1. Shall be random widths, and will not be furnished in specified widths, and shall be graded from the better side, but the reverse side shall not be of a lower grade than No. 1 shop or No. 1 barn.

2. Shall be 7 inches and wider, but will not be furnished wider than 12 inches; shall be 1 inch to 4 inches thick, 10 feet and longer. Pieces 10 inches and under in width shall admit two standard knots or their equivalent and an additional standard knot or its equivalent for every two inches in width over 10 inches. Pieces free from other defects, 10 inches and over in width, to admit pin wormholes on one edge one-tenth the width of the piece. Bright sap is not a defect in this grade. Slight wane on pieces 10 inches and over in width is al-

lowed on one edge not over 3 feet in length. When no other defect appears, slight amount of stained sap may be allowed. Pieces 10 inches and wider may admit of one end split, which shall not exceed in length the width of the piece.

Selected Common Tank Stock.

Shall be 4 inches wide, or wider, 1½ inches and 2 inches thick, 8 feet and over in length. Sound sap no defect in this grade, but must be free from unsound knots or other defects that extend through the thickness of the piece, and must be square edged to work the full length of the piece.

No. 1 Barn or Dimension.

Shall be specified widths only, shall be 3 inches and wider, 1 inch and thicker, 8 feet and over in length, admitting sap, bright or stained, shake, season checks, knots, pin wormholes a small amount of peck on one side and one edge, or very slight peck on both sides and both edges of pieces comparatively free from coarse defects; which defects, however, shall not be sufficient to seriously impair the strength, or prevent the use of each piece for "common" purposes in its full length and full width.

No. 2 Barn or Dimension.

Shall be specified widths, 3 inches and wider, 1 inch and thicker, 6 feet and over in length, admitting all the defects allowed in No. 1 barn, but same may be larger and coarser, and in addition will admit peck on both sides; however, the defects shall not be sufficient to prevent the use of each piece in full length and full width for low-grade fencing and other very common purposes.

Cull or Peck.

May be random or specified widths 3 inches and wider, 1 inch to 4 inches thick, 4 feet and over in length. Shall admit all pieces below the grade of No. 2 boxing, and shall also admit the product of that part of the log known as "pecky;" however, each piece shall have sufficient strength and nailing surface to permit its use as a low-grade boxing, crating, sheathing and foundation material.

Finishing.

1. Shall be specified widths 4 inches and wider, 1 inch to 2 inches thick, 10 feet and over in length, and shall be graded from the better side, A, B and C, but the reverse side should not be more than one grade lower. All grades of finish, rough or S1S or S2S may vary ¼ inch from the width specified.

2. "A" **Finish.**—Pieces 4 inches and 5 inches wide shall be clear of sap, knots and other defects. Pieces 6 inches wide may have 1 inch of bright sap, or, in lieu of sap, one small sound knot. Pieces 7 inches and 8 inches wide may have 2 inches of bright sap, or, in lieu of sap, one small sound knot. Pieces 9 inches and 10 inches wide may have 3 inches of bright sap, or, in lieu of sap, two small

sound knots, or 1½ inches of bright sap and one small sound knot. Pieces 12 inches wide may have 4 inches of bright sap, or, in lieu of sap, one standard knot, or two small sound knots, or two inches of bright sap and one small sound knot. Pieces 14 inches or wider may have more defects in proportion as the width increases.

3. "B" **Finish.**—Pieces 4 inches, 5 inches and 6 inches wide may have 2 inches of bright sap and one or two small sound knots, or in lieu of knots may have all bright sap. Pieces 7 inches and 8 inches wide may have 3 inches of bright sap and two small sound knots, or in lieu of knots may have all bright sap. Pieces 9 inches and 10 inches wide may have 4 inches of bright sap and one standard knot or three small sound knots, or in lieu of knots may have all bright sap. Pieces 12 inches wide may have 6 inches of bright sap and one standard or four small sound knots, or in lieu of knots may have all bright sap. This grade will not be furnished wider than 12 inches.

4. "C" **Finish.**—All widths in this grade shall admit small sound knots, stained sap, pin worms and other defects except shake; but none that will prevent the use of same in its full width and length as a paint grade, and will admit pieces containing one coarse defect which can be removed by making two cuts with a waste of not to exceed 5 per cent. in the one piece removed, but which pieces are otherwise "B" grade or better. This grade will not be furnished wider than 12 inches.

5. "D" **Finish.**—All widths will admit sound knots, stained sap, pin worms, slight shakes and other defects; but none that will prevent the use of same in its full width and length as a common paint grade. This grade will not be furnished wider than 12 inches.

Siding.

1. Siding shall be 4 inches and 6 inches in width, 10 feet to 20 feet in length, and graded from the finished side, A, B, C and D.

2. "A" **Siding.**—May have one inch of bright sap on thin edge and may contain one small sound knot.

3. "B" **Siding.**—May have any amount of bright sap, or, if not all bright sap, may have three small sound knots, shake, split or pin worm holes not exceeding in damage the three small knots as above, and may have slight wane on the thin edge. In the absence of other defects a small amount of stained sap will be permitted.

4. "C" **Siding.**—May have one to 5 knots, the whole not aggregating over 3 inches in diameter, or knots, splits or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have small amount of stained sap and pin worm holes not exceeding in damage the five small knots above described.

5. "D" **Siding.**—May have stained sap and pin worm holes, or may have other defects that will not cause a waste to exceed one-third the piece.

Flooring and Ceiling.

1. Shall be specified widths, 10 feet to 20 feet in length and graded from the finished side, or, if both sides are finished, it shall be graded from the better side, A, B, C and D.

2. "A"—May have bright sap on one edge one-fourth its width, otherwise must be clear.

3. "B"—May have one-half of its face bright sap if otherwise clear, or, in lieu of sap, may contain two small sound knots, or may have a split not to exceed 9 inches at one end.

4. "C" (10 to 20 feet)—May have all bright sap, or may have one to five knots, the whole not aggregating over 3 inches, or knots or other defects that can be removed in two cuts with waste not exceeding 10 per cent. of the length, or may have three pin worm holes, or may have check or split at one end, not to exceed 10 per cent. of the length.

5. "C" (4 to 9 feet)—May have all bright sap, small sound knots, stained sap, pin worm holes and other defects except shake, but none that will prevent the use of each piece the full length.

6. "D"—May have stained sap and pin worm holes, or may have unsound knots or other defects that will not cause a waste to exceed one-third the piece.

Partition.

Shall be same widths and lengths as floooring and ceiling, but shall be graded from the poorer side, A, B, C and D, same grading to apply as in flooring and ceiling.

Pickets.

1. Shall be graded No. 1 and No. 2.

2. 1 inch by 1 inch shall be Headed and S4S to $\frac{13}{16}$ inch by $\frac{13}{16}$ inch.

3. 1¼ inches by 1¼ inches shall be Headed and S4S to 1$\frac{1}{16}$ inches by 1$\frac{1}{16}$ inches.

4. 1½ inches by 1½ inches shall be Headed and S4S to 1$\frac{5}{16}$ inches by 1$\frac{5}{16}$ inches.

5. 1 inch by 3 inches shall be Headed and S4S to ¾ inch by 2½ inches.

6. No. 1—Shall be well manufactured, bright sap no defect, and may contain one small sound knot.

7. No. 2—Shall admit stained sap, sound knots, pin worm holes, slight shake, and pickets thrown out of the No. 1 grade because of poor manufacture.

Battens.

1. Battens, both flat and OG, are not moldings. Same are invariably used with "common" lumber and shall, therefore, be graded No. 1 barn and better, admitting all defects allowed in No. 1 barn, but none that will prevent the use of each piece in full length for batten pur-

poses. Three-eighths-inch battens shall be 1 inch strips S2S to 13/16 inch by 2½ inches and resawed, or 1 inch by 2¾ inches to 3 inches S2S and resawed. Unless otherwise specified, ⅜-inch or flat battens shall be S2S only and resawed.

2. OG battens shall be manufactured in the sizes and pattern shown in the Universal Molding Book.

Shingles.

1. **Bests.**—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, to be all heart and free of shake, knots and other defects.

2. **Primes.**—A dimension shingle, 4, 5 and 6 inches in width, 16 inches long, each width packed separately, 5 butts to measure 2 inches, admitting tight knots and sap, but free of shake and other defects, but with no knots within 8 inches of the butts.

3. This grade may contain shingles clipped two-thirds of the width and one-eighth of the length on the point.

4. **Star-a-Star.**—A random width shingle, 3 inches and wider, 14 inches to 16 inches long, otherwise the same as primes.

5. **Economy.**—Dimensions, 4, 5 and 6 inches, each width separately bunched, admitting sap and sound knots; may have slight peck 5 inches from butts, imperfections on points no objection and admitting 14-inch shingles.

6. **Clippers.**—All shingles below the above grades which are sound for 5 inches from butts, wormholes and slight peck excepted, random widths 2½ inches and wider.

7. The count of manufacture of shingles, of all grades, is based on 4,000 linear inches in width, making 1,000 standard shingles, consequently there would be only 667 6-inch shingles packed and counted as 1,000 standard shingles; 5 inches dimension being counted in like proportion.

8. In making re-inspection of shingles, one bundle out of 20 bundles, taken at random, shall be cut open, the results of this investigation to form the basis of arriving at the grade of the entire shipment.

Classification and Grading Rules for Hemlock Lumber.

SAP.

White or bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

WATER STAIN.

In hemlock will often be found streaks or patches of red or brown discolorations, sound and firm, the presence of which does not weaken the wood, nor detract seriously from its utility. Water stain should not be confused with rot, being firm and strong, while rot is soft and decayed wood.

Standard Sizes for Hemlock.

Rough Lumber.

Piece Stuff.

Standard lengths for Rough Piece Stuff are 4, 6, 8, 9, 10, 12, 14, 16, 18, 20, 22 and 24 ft. Standard widths are 4, 6, 8, 10 and 12 inches. Standard thickness is 1⅞ inches.

Boards.

Standard lengths for Rough Boards are 4, 6, 8, 10, 12, 14, 16, 18 and 20 ft. Standard widths are 4, 6, 8, 10 and 12 inches. Standard thickness is 15/16 inch.

Dressed Lumber.

Piece Stuff.

Standard sizes for Piece Stuff S1S1E are: 1¾x3¾, 1¾x5¾, 1¾x7¾, 1¾x9¾, 1¾x11¾.

Boards.

The standard thickness for inch lumber S1S is 13/16 inch.

Flooring, Ceiling, Shiplap, Drop Siding.

Standard widths are: 3¼, 5¼, 7¼, 9¼ and 11¼ in. face. Standard thickness is 13/16 in.

Estimated Weights of Hemlock Lumber.

Per M Feet, Shipping Dry

3 in. Plank, Rough	3,000
3 in. Plank and 4x4 to 8x8, S1S1E	2,700
3 in. Plank, S4S or D & M	2,500
4x10 to 12x12, Rough	3,500
4x10 to 12x12, S1S1E	3,200
4x4 to 8x8, Rough	3,000
Thick D & Better, S1S	2,500
Thick D & Better, S1S1	2,200
2 in. Piece Stuff, S1S1E	2,200
2 in. Piece Stuff, Rough or S1E	2,500
2 in. Piece Stuff, S4S or D & M	2,000
1 in. Boards, Rough	2,400
1 in. Boards, S1S or S2S	2,000
1 in. Clear and Select, S1S	2,000
Shiplap, D & M, or Drop Siding	1,800
1x6 Well Tubing, Beveled Edges	1,800
Sheathing Lath	1,500
Lath	500
32 in. Lath	300

Grading Rules.

Thick D and Better.

1. Thick D and Better shall be 4 in. wide and wider, 1¼ in., 1½ in. and dimension thickness.

2. This grade shall have sound, square edges, and be of grade of Inch D Stock and Better on the face side, and not below the grade of Inch No. 1 Common on the back of the piece.

Boards and Strips.

There are six grades made in Boards and Strips:

Inch Clear and Select.
Inch D Stock.
No. 1 Common.
No. 2 Common.
No. 3 Common.
No. 4 Common.

Inch Clear and Select.

1. Inch Clear and Select should be 4 in. and wider, and 8 ft. long and longer, not to exceed 10 per cent. 8 ft. long.

2. This grade is especially adapted for interior finish and only the face, or best side, is expected to show, although some attention should be given to the back of the piece.

3. The face shall show no wane, but the back may show such an amount of wane or other defects as will not interfere with the use of the piece for finishing purposes.

4. No shake or season check shall be allowed on the face side, but a very little tight shake and checks that are not deep may appear on the back of the piece.

5. This grade will admit on the face side several tight pin knots not over ⅜ in. in diameter. In a 4 or 6 in., 12 ft. and longer piece, not more than three knots are admissible, and proportionately more in a wider piece.

6. A 10 or 12 in. piece, 12 ft. and longer, will not admit of more than three sound, firmly set knots, not to exceed ¾ in. in diameter. Narrower and shorter pieces will admit of fewer large knots, but not a combination of large knots and other defects.

7. Pieces 12 ft. and longer are admissible that will, with not more than 10 per cent. of waste, produce two clear cuts, each four feet long or longer.

Inch D Stock.

1. Inch D Stock shall consist of Boards and Strips below the grade of Clear and Select 4 in. and wider, and 8 ft. long and longer, not to exceed 10 per cent. 8 ft. long, and must be of a sound and water-tight character.

2. All knots must be sound and firmly set. Red knots must not exceed 1¼ in. in diameter, and spike knots must not exceed in length one-fourth the width of the piece. Black knots must not exceed ¾ in. in diameter, and must be especially well set.

3. A 6-in. strip 12 ft. long shall not contain more than three defects of the extreme sizes. A wider or longer piece may contain relatively more of these defects, and narrower and shorter pieces relatively less. The general appearance of the piece must be taken into consideration.

4. No shake shall be allowed in this grade, but slight season checks and water stain shall not be considered defects.

5. This grade shall be suitable for sound Drop Siding, Ceiling and Flooring, and shall have a smooth appearance, especially on the edges.

Inch No. 1 Common.

1. The grade of No. 1 Common in Boards or Strips includes stock of a generally sound character.
2. Some shake is admissible.
3. Numerous knots, whether red or black.
4. Some water stain of a firm character.

Inch No. 2 Common.

1. Boards or Strips will admit of considerable shake.
2. Black, unsound knots.
3. Two or three good-sized knot holes, or more of small ones.
4. Streaks, or patches of discoloration, showing partial decay.
5. This grade can be safely recommended for general building purposes.

Inch No. 3 Common.

1. The defects may consist of excessive shake.
2. Very coarse, unsound knots.
3. Some soft rot.
4. Some cross checks.

Inch No. 4 Common.

4 In. and Wider, 4 Feet and Longer.

This grade includes all serviceable lumber below the grade of No. 3.

Piece Stuff or Dimension.

No. 1 Dimension.

1. The grade of No. 1 Dimension will admit of shake that will not materially affect the strength of the piece.

2. Also knots, either black or red, that are well located and fairly sound.

3. Or some slight cross checks or sound water stain.

4. This grade, while admitting the above defects, must at the same time retain the element of strength required for any building purpose.

No. 2 Dimension.

1. The grade of No. 2 Dimension includes stock not good enough to be classed as No. 1, and the defects admissible are of the same gen-

eral character as the defects found in No. 1, except that they are more pronounced.

2. Considerable shake, large unsound knots, loose knots, knot holes and cross checks are all admissible in this grade, but not a serious combination of these defects in any one piece.

Merchantable.

The grade of Merchantable is a combination of No. 1 and No. 2, consisting of approximately 50 per cent of each.

No. 3 Dimension.

1. The defects are excessive shake, numerous knot holes, coarse, rotten knots, or considerable rot.
2. This grade can be recommended for cheap, light construction.

No. 4 Dimension.

2x4 and Wider, 4 Feet and Longer.

This grade includes all serviceable Dimension below the grade of No. 3.

CLASSIFICATION OF THE USES OF LUMBER.

1. **Bridge and Construction Timber.**
   A. Combination and Howe Truss Spans.
      1. Compression members.
      2. Tension members.
      3. Diagonals subject to reversal of stress.
      4. Floor beams.
      5. Stringers.
      6. Ties.
      7. Guard timbers.
      8. Railing.
      9. Stiffeners.
      10. Splices.
      11. Nailing strips.
      12. Grillage.
      13. Deck plank.
      14. Bridging.

   B. Pile and Frame Trestles.
      1. Piles.
      2. Sills and mud sills.
      3. Posts.
      4. Caps.
      5. Cross bracing.
      6. Sash bracing.
      7. Longitudinal bracing.
      8. Girts.
      9. End plank.
      10. Stringers.
      11. Ties.
      12. Guard timbers.
      13. Planking for ballasted deck.
      14. Railing.

C. Falsework.
   1. Piles.
   2. Sills and mud sills.
   3. Posts.
   4. Caps.
   5. Stringers.
   6. Truss timbers.
   7. Centering.
   8. Lagging.
   9. Bracing.
   10. Wedges.
   11. Scaffolding.

D. Concrete Forms.
   1. Dimension lumber.
   2. D. & M. planks.
   3. Bracing.

E. Tanks and Supports.
   1. Piles.
   2. Sills.
   3. Posts.
   4. Caps.
   5. Bracing.
   6. Joists.
   7. D. & M. flooring.
   8. Staves.
   9. Rafters.
   10. Roof.
   11. Ladders, etc.
   12. Frost-box material.

F. Docks and Wharves.
   1. Piles.
   2. Timber sheet piling.
   3. Timber in cribs.
   4. Caps.
   5. Stringers.
   6. Bracing.
   7. Guard timber.
   8. Ties.
   9. Plank decking.
   10. Mooring posts.
   11. Fenders and wales.
   12. Warehouse. (See II.)

G. Coaling Stations and Ore Stations.
   1. Piles.
   2. Sills and mud sills.
   3. Posts.
   4. Caps.
   5. Bracing.
   6. Stringers.
   7. Joists.
   8. Bin lining.
   9. Rafters.
   10. Flooring.
   11. Chutes.
   12. Decking.
   13. Coal pockets or bins.
   14. Roofing.

2. Frame Buildings.

A. Station Buildings, Passenger, Freight, Platform Shelters.
   1. Piles.
   2. Caps.
   3. Sills.
   4. Posts.
   5. Stringers.
   6. Joists.
   7. Bridging.
   8. Sub-flooring.
   9. Finish flooring.
      (a) Pine.
      (b) Fir.
      (c) Maple or oak.
   10. Studding and plates.
   11. Sheathing.
   12. Furring.
   13. Siding.

14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
    (a) Mouldings.
    (b) Stairs.
    (c) Doors.
    (d) Windows.
25. Partitions.
26. Shelving.

B. Engine House.

1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Flooring.
9. Pit timbers.
10. Studding.
11. Sheathing.
12. Furring.
13. Siding.
14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
25. Sleepers.

C. Machine Shops.

1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Flooring.
9. Studding.
10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.
15. Truss timbers.
16. Purlins.
17. Rafters.
18. Roof boards.
19. Shingles.
20. Door and window frames.
21. Outside finish lumber.
22. Inside finish lumber.
23. Millwork.
24. Sleepers.

D. Section Houses.

1. Posts.
2. Sills.
3. Caps.
4. Stringers.
5. Joists.
6. Bridging.
7. Sub-flooring.
8. Finish flooring.
9. Studding and plates.
10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.

15. Rafters.
16. Roof boards.
17. Shingles.
18. Door and window frames.
19. Outside finish lumber.
20. Inside finish lumber.
21. Millwork.

E. Miscellaneous Small Buildings.

1. Posts.
2. Sills.
3. Caps.
4. Stringers.
5. Joists.
6. Bridging.
7. Sub-flooring.
8. Finish flooring.
9. Studding and plates.
10. Sheathing.
11. Furring.
12. Siding.
13. Ceiling.
14. Lath.
15. Rafters.
16. Roof boards.
17. Shingles.
18. Door and window frames.
19. Outside finish lumber.
20. Inside finish lumber.
21. Millwork.

F. Warehouses.

1. Piling.
2. Caps.
3. Sills.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Sub-flooring.
9. Finish flooring.
10. Studding and plates.
11. Sheathing.
12. Furring.
13. Siding.
14. Ceiling.
15. Lath.
16. Truss timbers.
17. Purlins.
18. Rafters.
19. Roof boards.
20. Shingles.
21. Door and window frames.
22. Outside finish lumber.
23. Inside finish lumber.
24. Millwork.
25. Sleepers.

G. Ice Houses.

1. Piling.
2. Sills.
3. Caps.
4. Posts.
5. Stringers.
6. Joists.
7. Bridging.
8. Sleepers.
9. Sub-flooring.
10. Finish flooring.
11. Studding.
12. Sheathing.
13. Furring.
14. Siding.
15. Ceiling.
16. Lath.
17. Truss timbers.
18. Purlins.
19. Rafters.
20. Roof boards.
21. Shingles.
22. Door and window frames.
23. Outside finish lumber.
24. Inside finish lumber.
25. Millwork.

3. Ties.

A. Cross-Ties.

B. Switch Ties.

4. Miscellaneous Roadway Material.

- A. Crossing Plank.
- B. Platforms.
    - 1. Posts.
    - 2. Caps.
    - 3. Sills.
    - 4. Stringers.
    - 5. Joists.
    - 6. Bridging.
    - 7. Planking.
    - 8. Railing.
    - 9. Steps.
    - 10. Skids.
- C. Stock Guards.
    - 1. Posts.
    - 2. Ties.
    - 3. Wing fences and aprons.
    - 4. Slats.
    - 5. Fillers.
- D Signs and Posts.
    - 1 Posts.
    - 2. Bracing.
    - 3. Sign boards.
    - 4. Moulding.
- E. Fencing, Including Snow Fence.
    - 1. Posts.
    - 2. Bracing.
    - 3. Stringers.
    - 4. Fence boards.
    - 5. Gate material.
    - 6. Stakes.
- F. Culverts and Drains.
    - 1. Sills.
    - 2. Bracing.
    - 3. Timbers.
    - 4. Planking.
    - 5. Grillage.
- G. Stock Pens.
    - 1. Posts.
    - 2. Sills.
    - 3. Fencing.
    - 4. Studding.
    - 5. Sheathing.
    - 6. Rafters.
    - 7. Roof boards.
    - 8. Shingles.
    - 9. Outside finish lumber.
- H. Poles.
- I. Conduits.
- J. Bumping Blocks.
- K. Cross-arms.

COMMITTEE VIII.

MASONRY.

[1] DEFINITIONS.

Abutment.—A supporting wall carrying the end of a bridge or span and generally sustaining the pressure of the abutting earth.

Arch Masonry.—That portion of the masonry in the arch ring only, or between the intrados and the extrados.

Arris.—The external edge formed by two surfaces, whether plain or curved, meeting each other.

Batter.—The slope or inclination of the face or back of a wall from a vertical plane.

Bench Wall.—The abutment from which an arch springs.

Cement.—A material of one of the two classes, Portland and natural, possessing the property of hardening into a solid mass when mixed with water.

Cement, Natural.—Natural cement is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Cement, Portland.—Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

Centering.—A temporary support used in arch construction. (Also called centers.)

Coping.—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Culvert.—A covered passage for water under a roadway or embankment.

Dowels.—Metal bars used to connect two sections of masonry. (See definition of "Dowel" under "Stone and Brick Masonry.")

Extrados.—The outer or convex surface of an arch.

Final Set.—A stage of the process of setting marked by certain hardness. (See Cement Specifications.)

---

[1] Adopted, Vol. 7, 1906, pp. 596-601, 619; Vol. 12, Part 1, 1911, pp. 478, 579; Vol. 16, 1915, pp. 794, 1175; Vol. 19, 1918, pp. 721, 1227; Vol. 21, 1920, pp. 84, 1354.

Flush (adj.).—Having the surface even or level with an adjacent surface.

Flush (verb).—(1) To fill. (2) To bring to a level. (3) To force water to the surface of mortar or concrete by compacting or ramming.

Footing.—A bottom course.

Foundation.—(1) That portion of a structure usually below the surface of the ground, which distributes the pressure upon its support. (2) Also applied to the natural support itself; rock, clay, etc.

Foundation Bed.—The surface on which a structure rests.

Grout (noun).—The material resulting from mixing cement and water, or cement, sand and water, to a fluid consistency.

Initial Set.—An early stage of the process of setting, marked by certain hardness. (See Cement Specifications.)

Intrados.—The inner or concave surface of an arch.

Lagging.—Strips used to carry and distribute the weight of an arch to the ribs or centering during its construction.

Lock.—Any special device or method of construction used to secure a bond in the work.

Masonry.—Masonry, in its widest sense, includes all construction of stone or kindred substitute materials, in which the separate pieces are either placed together, with or without cementing material to join them; or encased in a matrix of firmly cementing material.

In usual practice, the word "Masonry" is qualified by some proper term to more particularly describe the masonry under consideration, such as stone, concrete, brick, etc.

Mortar.—A mixture of fine aggregate, cement or lime and water used to bind together the materials of concrete, stone or brick in masonry or to cover the surface of the same.

Parapet.—A wall or barrier on the edge of an elevated structure for protection or ornament.

Pier.—An intermediate support for arches or other spans.

Pointing.—Filling joints or defects in the face of a masonry structure.

Retaining Wall.—A wall for sustaining the pressure of earth or filling deposited behind it.

Sand.—(See definition under "Concrete Masonry.")

Set (noun).—The change from a plastic to a solid or hard state.

Slope Wall.—A wall to protect the slope of an embankment or cut.

Soffit.—The under side of a projection.

Spandrel Wall.—The wall at the end of an arch above the springing line and extrados of the arch and below the coping or the string course.

Standard Sand.—(See definition under "Concrete Masonry.")

Wing Wall.—An extension of an abutment wall to retain the adjacent earth.

Stone and Brick Masonry.

Ashlar.—A squared or cut block of stone of rectangular dimensions.

Backing.—That portion of a masonry wall or structure built in the rear of the face.

Bed.—The top or bottom of a stone. (See Course Bed; Natural Bed; Foundation Bed.)

Bed Joint.—A horizontal joint, or one perpendicular to the line of pressure.

Bond.—In stone or brick masonry, the mechanical disposition of stone, brick or other building blocks by overlapping to break joints. (See English Bond; Flemish Bond.)

Broken Coursed.—Laid with parallel, but not continuous, bed joints. (See Coursed; Uncoursed.)

Build.—A vertical joint.

Clamp.—An instrument for lifting stone so designed that its grip on the surface of the stone is increased as the load is applied. That portion engaging the stone is of wood attached to a steel shoe, which in turn is hinged to the shank of the clamp in such a manner as to adjust itself to the surface of the body lifted.

Course.—Each separate layer in stone or brick masonry.

Course Bed.—Stone, brick or other building material in position, upon which other material is to be laid.

Coursed.—Laid with continuous bed joints. (See Broken Coursed; Uncoursed.)

Cramps.—Bars of iron having the ends turned at right angles to the body of the bar which enter holes in the upper side of adjacent stones.

Dimension Stone.—A block of stone cut to specified dimensions.

Dowel.—A two-piece steel instrument used in lifting stone. The dowel engages the stone by means of two holes drilled into the stone at an angle of about 45 degrees pointing toward each other. The dowel is not keyed in place. (See definition of Dowel under General Definitions.)

Draft.—A line on the surface of a stone cut to the breadth of the chisel.

Dressing.—The finish given to the surface of stones. (See Smooth; Fine-Pointed; Rough-Pointed; Scabbled; Rock-Faced.)

Dry Masonry.—Masonry in which stones are built up without the use of mortar. (See Masonry under General Definitions.)

English Bond.—That disposition of bricks in a structure in which each alternate course is composed entirely of headers or of stretchers. (See Bond.)

Fine Pointed.—Having irregular surface, the variations of which do not exceed one-quarter inch from the pitch line. (See Dressing.)

Flemish Bond.—That disposition of bricks in a structure in which the headers and stretchers alternate in each course, the header being so placed that the outer end lies on the middle of a stretcher in the course below. (See Bond.)

Header.—A stone which has its greatest length at right angles to the face of the wall, and which bonds the face stones to the backing.

Joint.—The narrow space between adjacent stones, bricks or other building blocks, usually filled with mortar.

Lewis.—A four-piece steel instrument used in lifting stone. (The lewis engages the stone by means of a triangular-shaped hole into which it is keyed.)

Natural Bed.—The surfaces of a stone parallel to its stratification.

Paving.—Regularly placed stone or brick forming a floor.

Pitch (verb).—To square a stone.

Pitched.—Having the arris clearly defined by a line beyond which the rock is cut away by the pitching chisel so as to make approximately true edges.

Ring Stones.—The end voussoirs of an arch.

Riprap.—Rough stone of various sizes placed compactly or irregularly to prevent scour by water.

Rock-Faced.—Presenting irregular projecting face, without indications of tool mark. (See Dressing.)

Rough Pointed.—Having irregular surface, the variations of which do not exceed one-half inch from the pitch line. (See Dressing.)

Rubbed.—A fine finish made by rubbing with grit or sandstone.

Rubble.—Field stone or rough stone as it comes from the quarry. When it is of a large or massive size it is termed block rubble.

Scabbled.—Having irregular surface, the variations of which do not exceed three-quarters inch from the pitch line. (See Dressing.)

Smooth.—Having surface, the variations of which do not exceed one-sixteenth inch from the pitch line. (See Dressing.)

Spall (noun).—A chip or small piece of stone broken from a large block.

Stretcher.—A stone which has its greatest length parallel to the face of the wall.

Uncoursed.—Laid without regard to courses. (See Coursed; Broken Coursed.)

Voussoirs.—The individual stones forming an arch. They are always of truncated wedge form.

Concrete Masonry.

Acid Treated Finish.—Having surface formed by dissolving cement with acid together with scrubbing to expose the aggregate. (See Finish.)

Aggregate.—The inert material used in making concrete. (See Pre-mixed Aggregate; Fine Aggregate; Coarse Aggregate.)

Cast-in-place Piles.—Piles which are cast in holes in the ground. (See Pre-molded Concrete Piles.)

Coarse Aggregate.—The coarser inert material used in making concrete, usually considered to include that material which is retained on a sieve having four meshes per linear inch. The upper limit of its size depends on various conditions, but it seldom exceeds three inches. (See Aggregate.)

Concrete.—A compact mass of broken stone, gravel or other suitable material assembled together with cement mortar and allowed to harden. (See Reinforced Concrete; Rubble Concrete.)

Construction Joint.—A joint or break between successive deposits of concrete, usually to facilitate construction. (See Expansion Joint.)

Course.—Each separate layer in concrete. (See definition under Stone and Brick Masonry.)

Crushed Slag.—Air-cooled, blast-furnace slag of sizes included under "Coarse Aggregate."

Crushed Stone.—Crushed natural rock of sizes defined under "Coarse Aggregate."

Crusher-Run Rock.—The unscreened output of the stone crusher.

Expansion Joint.—A joint or break in the mass concrete to provide for expansion. (See Construction Joint.)

Faced Surfaces.—Having surface formed by placing a special aggregate not less than one inch next to the forms and contiguous with the body concrete. (See Finish.)

Fine Aggregate.—The finer inert material used in making concrete, usually considered to include that material passing a sieve having four meshes per linear inch. (See Aggregate.)

Finish.—The finish given to surfaces of concrete. (See Acid-Treated Finish; Faced Surfaces; Rubbed Finish; Sand Blast Finish; Spaded Finish; Tooled Finish; Unfaced Surface; Washed or Scrubbed Finish.)

Form.—A temporary structure in which to cast concrete.

Gravel, Bank-Run Gravel.—Normal product of a gravel bank, including pebbles and sand in varying proportions.

Joint.—(See Construction Joint; Expansion Joint.)

Laitance.—A film or layer consisting principally of the finer cement particles which rise to the surface during the placing of the concrete.

Mixer-Batch.—A machine for mixing concrete in separate batches as distinguished from concrete mixed by a continuous mixer.

Monolithic Concrete Construction.—Monolithic concrete construction is the building of a mass of concrete without joints by a continuous operation.

Pre-Mixed Aggregate.—A mixture of fine and coarse aggregate. (See Aggregate.)

Pre-molded Concrete Piles.—Piles which are molded previous to driving. (See Cast-in-place Piles.)

Reinforced Concrete.—Concrete in which steel or other metal is embedded in such a manner that both concrete and metal act in unison to resist stresses. (See Concrete.)

Rubbed Finish.—Having surface treated by rubbing with Carborundum or cement bricks, or wooden floats to remove all form marks and irregularities. (See Finish.)

Rubble Concrete.—Concrete in which rubble stone are embedded. (See Concrete.)

Sand.—The finely divided material, generally of a siliceous nature, resulting from the reduction of rock by natural forces to the size included under fine aggregate. (See Standard Sand.)

Sand Blast Finish.—Having surface formed by the wearing effect of the sand blast. (See Finish.)

Spaded Finish.—Having surface formed by spading coarse aggregate back from the form into the mass concrete, so as to bring a surface of mortar next to the form. (See Finish.)

Standard Sand.—A natural sand from Ottawa, Ill., screened to pass a No. 20 sieve, and retained on a No. 30 sieve.

Stone Screenings.—Crushed natural rock of sizes defined under "Fine Aggregate." (See Aggregate.)

Tooled Finish.—Having surface formed by dressing with bush hammer, crandall or other desired tool to a uniform depth and finish. (See Finish.)

Tremie.—A cylindrical or other form of tube, with sloped top or pocket used for depositing concrete in water.

Unfaced Surface.—Having surface formed by careful grading of the entire mass mixture and spading mixture to prevent voids leaving the coarse aggregate next to the forms. (See Finish.)

Washed or Scrubbed Finish.—Having surface formed by rubbing or scrubbing to expose the aggregate.

[2]SPECIFICATIONS FOR PORTLAND CEMENT.

Definition.

1. Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

(I) Chemical Properties.

Chemical Limits:

2. The following limits shall not be exceeded:

Loss on ignition, per cent	4.00
Insoluble residue, per cent	0.85
Sulphuric anhydride (SO_3), per cent	2.00
Magnesia (MgO), per cent	5.00

---

[2] Adopted, Vol. 18, 1917, pp. 888, 1565.

(II) PHYSICAL PROPERTIES.

Specific Gravity.

3. The specific gravity of cement shall be not less than 3.10 (3.07 for white Portland cement). Should the test of cement as received fall below this requirement a second test may be made upon an ignited sample. The specific gravity test will not be made unless specifically ordered.

Fineness.

4. The residue on a standard No. 200 sieve shall not exceed 22 per cent. by weight.

Soundness.

5. A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking or disintegration in the steam test for soundness.

Time of Setting.

6. The cement shall not develop initial set in less than 45 minutes when the Vicat needle is used or 60 minutes when the Gillmore needle is used. Final set shall be attained within 10 hours.

Tensile Strength.

7. The average tensile strength in pounds per square inch of not less than three standard mortar briquettes (see Section 51), composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

Age at Test, days.	Storage of Briquettes.	Tensile Strength, lb. per sq. in.
7	1 day in moist air, 6 days in water........	200
28	1 day in moist air, 27 days in water......	300

8. The average tensile strength of standard mortar at 28 days shall be higher than the strength at 7 days.

(III) PACKAGES, MARKING AND STORAGE.

Packages and Marking.

9. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. A bag shall contain 94 lb. net. A barrel shall contain 376 lb. net.

Storage.

10. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.

(IV) INSPECTION.

Inspection.

11. Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test. The cement shall be tested in accordance with the methods hereinafter prescribed. The 28-day test shall be waived only when specifically so ordered.

(V) REJECTION.

Rejection.

12. The cement may be rejected if it fails to meet any of the requirements of these specifications.

13. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest after drying at 100 degrees Centigrade for one hour it meets this requirement.

14. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest using a new sample at any time within 28 days thereafter.

15. Packages varying more than 5 per cent. from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

Tests.

(VI) SAMPLING.

Number of Samples.

16. Tests may be made on individual or composite samples as may be ordered. Each test sample should weigh at least 8 lb.

17. (*a*) *Individual Sample.*—If sampled in cars, one test sample shall be taken from each 50 barrels or fraction thereof. If sampled in bins, one sample shall be taken from each 100 barrels.

(*b*) *Composite Sample.*—If sampled in cars, one sample shall be taken from one sack in each 40 sacks (or 1 barrel in each 10 barrels) and combined to form one test sample. If sampled in bins or warehouses, one test sample shall represent not more than 200 barrels.

Method of Sampling.

18. Cement may be sampled at the mill by any of the following methods that may be practicable, as ordered:

(*a*) *From the Conveyor Delivering to the Bin.*—At least 8 lb. of cement shall be taken from approximately each 100 barrels passing over the conveyor.

(*b*) *From Filled Bins by Means of Proper Sampling Tubes.*—Tubes inserted vertically may be used for sampling cement to a maximum depth of 10 ft. Tubes inserted horizontally may be used where the construction of the bin permits. Samples shall be taken from points well distributed over the face of the bin.

(*c*) *From Filled Bins at Points of Discharge.*—Sufficient cement shall be drawn from the discharge openings to obtain samples representative of the cement contained in the bin, as determined by the appearance at the discharge openings of indicators placed on the surface of the cement directly above these openings before drawing of the cement is started.

Treatment of Sample.

19. Samples preferably shall be shipped and stored in air-tight containers. Samples shall be passed through a sieve having 20 meshes per linear inch in order to thoroughly mix the sample, break up lumps and remove foreign materials.

(VII) CHEMICAL ANALYSIS.

LOSS ON IGNITION.

Method.

20. One gram of cement shall be heated in a weighed covered platinum crucible, of 20 to 25 cc. capacity, as follows, using either method (*a*) or (*b*) as ordered:

(*a*) The crucible shall be placed in a hole in an asbestos board, clamped horizontally so that about three-fifths of the crucible projects below, and blasted at a full red heat for 15 minutes with an inclined flame; the loss in weight shall be checked by a second blasting for 5 minutes. Care shall be taken to wipe off particles of asbestos that may adhere to the crucible when withdrawn from the hole in the board. Greater neatness and shortening of the time of heating are secured by making a hole to fit the crucible in a circular disk of sheet platinum and placing this disk over a somewhat larger hole in an asbestos board.

(*b*) The crucible shall be placed in a muffle at any temperature between 900 and 1,000 degrees Centigrade for 15 minutes and the loss in weight shall be checked by a second heating for 5 minutes.

Permissible Variation.

21. A permissible variation of 0.25 will be allowed, and all results in excess of the specified limit, but within this permissible variation, shall be reported as 4 per cent.

INSOLUBLE RESIDUE.

Method.

22. To a 1-gr. sample of cement shall be added 10 cc. of water and 5 cc. of concentrated hydrochloric acid; the liquid shall be warmed until effervescence ceases. The solution shall be diluted to 50 cc. and digested

on a steam bath or hot plate until it is evident that decomposition of the cement is complete. The residue shall be filtered, washed with cold water, and the filter paper and contents digested in about 30 cc. of a 5 per cent. solution of sodium carbonate, the liquid being held at a temperature just short of boiling for 15 minutes. The remaining residue shall be filtered, washed with cold water, then with a few drops of hot hydrochloric acid, 1:9, and finally with hot water, and then ignited at a red heat and weighed as the insoluble residue.

Permissible Variation.

23. A permissible variation of 0.15 will be allowed, and all results in excess of the specified limit, but within this permissible variation, shall be reported as 0.85 per cent.

Sulphuric Anhydride.

Method.

24. One gram of the cement shall be dissolved in 5 cc. of concentrated hydrochloric acid diluted with 5 cc. of water, with gentle warming; when solution is complete 40 cc. of water shall be added, the solution filtered, and the residue washed thoroughly with water. The solution shall be diluted to 250 cc. heated to boiling, and 10 cc. of a hot 10 per cent. solution of barium chloride shall be added slowly, drop by drop, from a pipette and the boiling continued until the precipitate is well formed. The solution shall be digested on the steam bath until the precipitate has settled. The precipitate shall be filtered, washed, and the paper and contents placed in a weighed platinum crucible and the paper slowly charred and consumed without flaming. The barium sulphate shall then be ignited and weighed. The weight obtained multiplied by 34.3 gives the percentage of sulphuric anhydride. The acid filtrate obtained in the determination of the insoluble residue may be used for the estimation of sulphuric anhydride instead of using a separate sample.

Permissible Variation.

25. A permissible variation of 0.10 will be allowed, and all results in excess of the specified limit, but within this permissible variation, shall be reported as 2.00 per cent.

Magnesia.

Method.

26. To 0.5 gr. of the cement in an evaporating dish shall be added 10 cc. of water to prevent lumping, and then 10 cc. of concentrated hydrochloric acid. The liquid shall be gently heated and agitated until attack is complete. The solution shall then be evaporated to complete dryness on a steam or water bath. To hasten dehydration the residue may be heated to 150 or even 200 degrees Centigrade for one-half to one hour. The residue shall be treated with 10 cc. of concentrated hydrochloric

acid diluted with an equal amount of water. The dish shall be covered and the solution digested for ten minutes on a steam bath or water bath. The diluted solution shall be filtered and the separated silica washed thoroughly with water.* Five cubic centimeters of concentrated hydrochloric acid and sufficient bromine water to precipitate any manganese which may be present shall be added to the filtrate (about 250 cc.). This shall be made alkaline with ammonium hydroxide, boiled until there is but a faint odor of ammonia, and the precipitated iron and aluminum hydroxides, after settling, shall be washed with hot water, once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate shall be transferred by a jet of hot water to the precipitating vessel and dissolved in 10 cc. of hot hydrochloric acid. The paper shall be extracted with acid, the solution and washings being added to the main solution. The aluminum and iron shall then be reprecipitated at boiling heat by ammonium hydroxide and bromine water in a volume of about 100 cc., and the second precipitate shall be collected and washed on the filter used in the first instance if this is still intact. To the combined filtrates from the hydroxides of iron and aluminum, reduced in volume if need be, 1 cc. of ammonium hydroxide shall be added, the solution brought to boiling, 25 cc. of a saturated solution of boiling ammonium oxalate added, and the boiling continued until the precipitated calcium oxalate has assumed a well-defined granular form. The precipitate after one hour shall be filtered and washed, then with the filter shall be placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner; after ignition, it shall be redissolved in hydrochloric acid and the solution diluted to 100 cc. Ammonia shall be added in slight excess and the liquid boiled. The lime shall then be reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed. The combined filtrates from the calcium precipitates shall be acidified with hydrochloric acid, concentrated on the steam bath to about 150 cc., and made slightly alkaline with ammonium hydroxide, boiled and filtered (to remove a little aluminum and iron and perhaps calcium). When cool, 10 cc. of saturated solution of sodium-ammonium-hydrogen phosphate shall be added with constant stirring. When the crystallin ammonium-magnesium orthophosphate has formed, ammonia shall be added in moderate excess. The solution shall be set aside for several hours in a cool place, filtered and washed with water containing 2.5 per cent. of NH_3. The precipitate shall be dissolved in a small quantity of hot hydrochloric acid, the solution diluted to about 100 cc., 1 cc. of a saturated solution of sodium-ammonium-hydrogen phosphate added, and ammonia drop by drop, with constant stirring, until the precipitate is again formed as described and the ammonia is in moderate excess. The precipitate shall then be allowed to stand about two hours, filtered and washed as before. The paper and contents shall be placed in a weighed platinum crucible, the paper slowly charred, and the resulting carbon carefully burned off. The precipitate shall then be ignited to constant weight over a Meker burner, or a blast not strong enough to soften or melt the pyrophosphate. The weight of magnesium pyrophosphate obtained multiplied by 72.5 gives the percentage of magnesia. The precipitate so obtained always contains some calcium and usually small quantities of iron, aluminum and manganese as phosphates.

---

*Since this procedure does not involve the determination of silica, a second evaporation is unnecessary.

Permissible Variation.

27. A permissible variation of 0.4 will be allowed, and all results in excess of the specified limit, but within this permissible variation, shall be reported as 5.00 per cent.

(VIII) DETERMINATION OF SPECIFIC GRAVITY.

Apparatus.

28. The determination of specific gravity shall be made with a standardized Le Chatelier apparatus which conforms to the requirements illustrated in Fig. 1. This apparatus is standardized by the United States Bureau of Standards. Kerosene free from water, or benzine not lighter than 62 degrees Baumé, shall be used in making this determination.

Method.

29. The flask shall be filled with either of these liquids to a point on the stem between zero and one cubic centimeter, and 64 g. of cement, of the same temperature as the liquid, shall be slowly introduced, taking care that the cement does not adhere to the inside of the flask above the liquid and to free the cement from air by rolling the flask in an inclined position. After all the cement is introduced, the level of the liquid will rise to some division of the graduated neck; the difference between readings is the volume displaced by 64 g. of the cement.

The specific gravity shall then be obtained from the formula:

$$\text{Specific gravity} = \frac{\text{Weight of cement (g.)}}{\text{Displaced volume (cc.)}}$$

30. The flask, during the operation, shall be kept immersed in water, in order to avoid variations in the temperature of the liquid in the flask, which shall not exceed 0.5 degrees Centigrade. The results of repeated tests should agree within 0.01.

31. The determination of specific gravity shall be made on the cement as received; if it falls below 3.10, a second determination shall be made after igniting the sample as described in Section 20.

(IX) DETERMINATION OF FINENESS.

Apparatus.

32. Wire cloth for standard sieves for cement shall be woven (not twilled) from brass, bronze, or other suitable wire, and mounted without distortion on frames not less than 1½ in. below the top of the frame. The sieve frames shall be circular, approximately 8 in. in diameter, and may be provided with a pan and cover.

33. A standard No. 200 sieve is one having nominally an 0.0029-in. opening and 200 wires per inch standardized by the United States Bureau of Standards, and conforming to the following requirements:

The No. 200 sieve should have 200 wires per inch, and the number of wires in any whole inch shall not be outside the limits of 192 to 208. No opening between adjacent parallel wires shall be more than 0.0050-in. in width. The diameter of the wire should be 0.0021-in. and the average diameter shall not be outside the limits 0.0019 to 0.0023-in. The value of the sieve as determined by sieving tests made in conformity with the standard specification for these tests on a standardized cement which gives a residue of 25 to 50 per cent. on the No. 200 sieve, or on other similarly graded material, shall not allow a variation of more than 1.5 per cent. above or below the standards maintained at the Bureau of Standards.

Method.

34. The test shall be made with 50 g. of cement. The sieve shall be thoroughly clean and dry. The cement shall be placed on the No. 200 sieve, with pan and cover attached, if desired, and shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. The sieve shall be turned every 25 strokes about one-sixth of a revolution in the same direction. The operation shall continue until not more than 0.05 g. passes through in one minute of continuous sieving. The fineness shall be determined from the weight of the residue on the sieve expressed as a percentage of the weight of the original sample.

35. Mechanical sieving devices may be used, but the cement shall not be rejected if it meets the fineness requirement when tested by the hand method described in Section 34.

Permissible Variation.

36. A permissible variation of 1 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 22 per cent.

(X) MIXING CEMENT PASTES AND MORTARS.

Method.

37. The quantity of dry material to be mixed at one time shall not exceed 1,000 g. nor be of less than 500 g. The proportions of cement or cement and sand shall be stated by weight in grams of the dry materials; the quantity of water shall be expressed in cubic centimeters (1 cc. of water = 1 g.). The dry materials shall be weighed, placed upon a non-absorbent surface, thoroughly mixed dry if sand is used, and a crater formed in the center, into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the

crater by the aid of a trowel. After an interval of ½ minute for the absorption of the water the operation shall be completed by continuous, vigorous mixing, squeezing and kneading with the hands for at least one minute.* During the operation of mixing, the hands should be protected by rubber gloves.

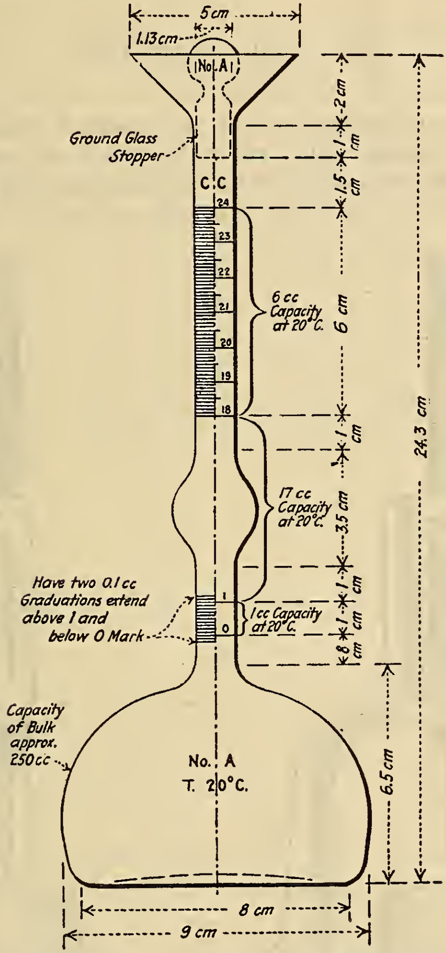


FIG. 1.—LE CHATELIER APPARATUS.

---

*In order to secure uniformity in the results of tests for the time of setting and tensile strength the manner of mixing above described should be carefully followed. At least one minute is necessary to obtain the desired plasticity which is not appreciably affected by continuing the mixing for several minutes. The exact time necessary is dependent upon the personal equation of the operator. The error in mixing should be on the side of overmixing.

38. The temperature of the room and the mixing water shall be maintained as nearly as practicable at 21 degrees Centigrade (70 degrees Fahrenheit).

(XI) NORMAL CONSISTENCY.

Apparatus.

39. The Vicat apparatus consists of a frame *A* (Fig. 2) bearing a movable rod *B*, weighing 300 g., one end *C* being 1 cm. in diameter for a distance of 6 cm., the other having a removable needle *D*, 1 mm. in diameter, 6 cm. long. The rod is reversible, and can be held in any desired position by a screw *E*, and has midway between the ends a mark *F*, which moves under a scale (graduated to millimeters) attached to the frame *A*. The paste is held in a conical, hard-rubber ring, *G*, 7 cm. in diameter at the base, 4 cm. high, resting on a glass plate *H* about 10 cm. square.

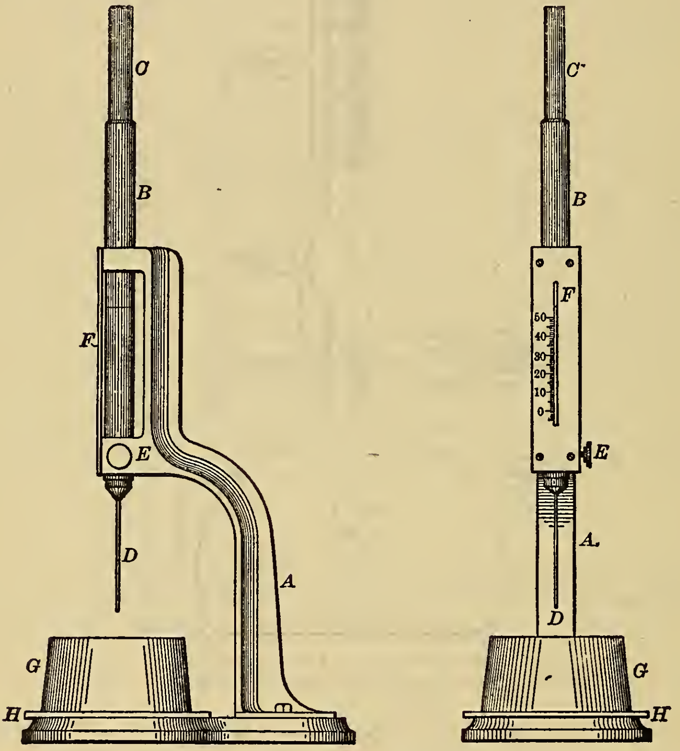


FIG. 2.—VICAT APPARATUS.

Method.

40. In making the determination, 500 g. of cement, with a measured quantity of water, shall be kneaded into a paste, as described in Section 37, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 in. apart; the ball resting in the palm of one hand shall be pressed into the larger end of the rubber ring held in the other hand, completely filling the ring with paste; the excess at the larger end shall then be removed by a single movement of the palm of the hand; the ring shall then be placed on its larger end on a glass plate and the excess paste at the smaller end sliced off at the top of the ring by a single oblique stroke of a trowel held at a slight angle with the top of the ring. During these operations care shall be taken not to compress the paste. The paste confined in the ring, resting on the plate, shall be placed under the rod, the larger end of which shall be brought in contact with the surface of the paste; the scale shall be then read, and the rod quickly released. The paste shall be of normal consistency when the rod settles to a point 10 mm. below the original surface in ½ minute after being released. The apparatus shall be free from all vibrations during the test. Trial pastes shall be made with varying percentages of water until the normal consistency is obtained. The amount of water required shall be expressed in percentage by weight of the dry cement.

TABLE 1.—PERCENTAGE OF WATER FOR STANDARD MORTARS.

Percentage of Water for Neat Cement Paste of Normal Consistency.	Percentage of Water for One Cement Three Standard Ottawa Sand.	Percentage of Water for Neat Cement Paste of Normal Consistency.	Percentage of Water for One Cement Three Standard Ottawa Sand.
15	9.0	23	10.3
16	9.2	24	10.5
17	9.3	25	10.7
18	9.5	26	10.8
19	9.7	27	11.0
20	9.8	28	11.2
21	10.0	29	11.3
22	10.2	30	11.5

41. The consistency of standard mortar shall depend on the amount of water required to produce a paste of normal consistency from the same sample of cement. Having determined the normal consistency of the sample, the consistency of standard mortar made from the same sample shall be as indicated in Table 1, the values being in percentage of the combined dry weights of the cement and standard sand.

(XII) *Determination of Soundness.

Apparatus.

42. A steam apparatus, which can be maintained at a temperature between 98 and 100 degrees Centigrade, or one similar to that shown in Fig. 3, is recommended. The capacity of this apparatus may be increased by using a rack for holding the pats in a vertical or inclined position.

Method.

43. A pat from cement paste of normal consistency about 3 inches in diameter, ½ in. thick at the center, and tapering to a thin edge, shall be made on clean glass plates about 4 in. square, and stored in moist air for 24 hours. In molding the pat, the cement paste shall first be flattened on the glass and the pat then formed by drawing the trowel from the outer edge toward the center.

44. The pat shall then be placed in an atmosphere of steam at a temperature between 98 and 100 degrees Centigrade upon a suitable support 1 in. above boiling water for 5 hours.

45. Should the pat leave the plate, distortion may be detected best with a straight edge applied to the surface which was in contact with the plate.

(XIII) Determination of Time of Setting.

46. The following are alternate methods, either of which may be used as ordered:

Vicat Apparatus.

47. The time of setting shall be determined with the Vicat apparatus described in Section 39. (See Fig. 2.)

Vicat Method.

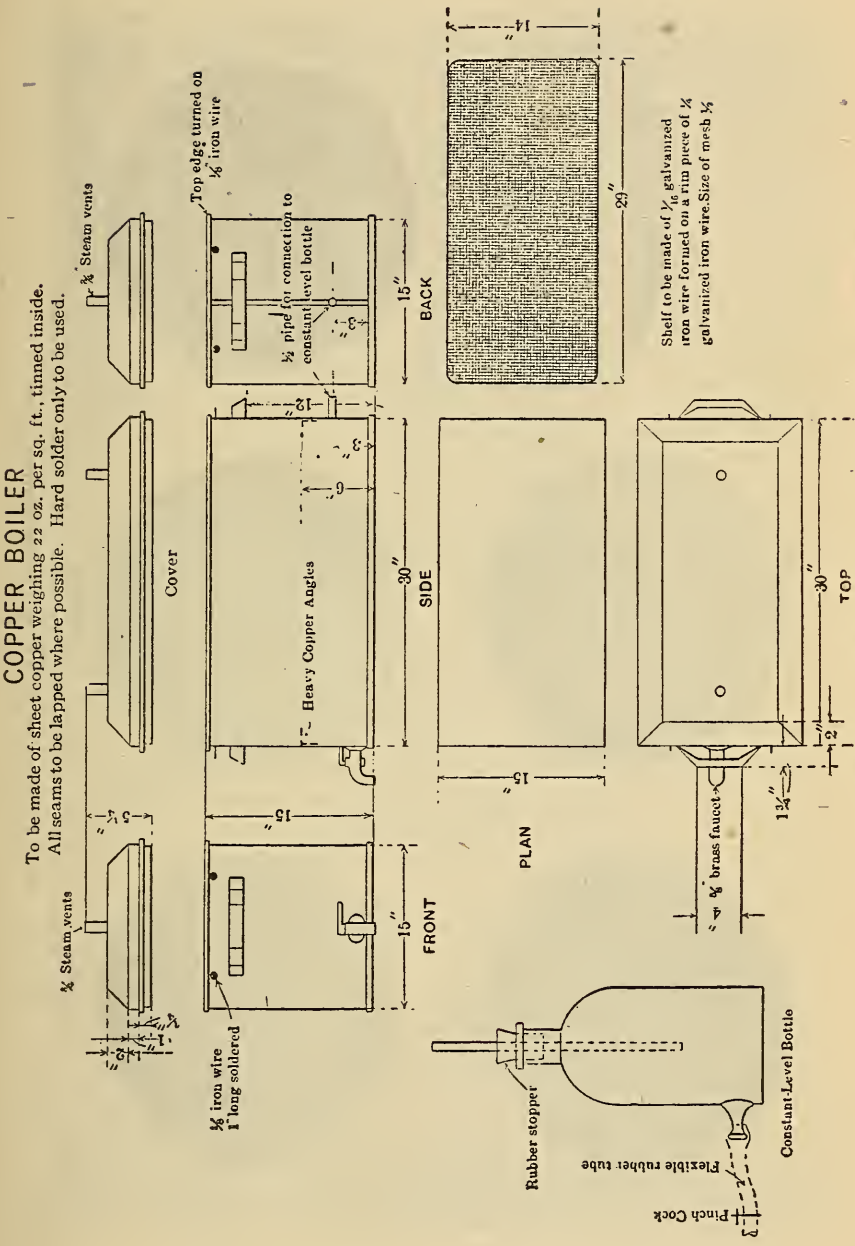
48. A paste of normal consistency shall be molded in the hard rubber ring *G* as described in Section 40, and placed under the rod *B*, the smaller end of which shall then be carefully brought in contact with the surface of the paste, and the rod quickly released. The initial set shall be said to have occurred when the needle ceases to pass a point 5 mm. above the glass plate in ½ minute after being released; and the final set, when the needle does not sink visibly into the paste. The test pieces shall be kept in moist air during the test. This may be accomplished by placing them on a rack over water contained in a pan and covered by a damp cloth, kept from contact with them by means of a wire screen; or they may be

---

*Unsoundness is usually manifested by change in volume which causes distortion, cracking, checking or disintegration.

Pats improperly made or exposed to drying may develop what are known as shrinkage cracks within the first 24 hours and are not an indication of unsoundness. These conditions are illustrated in Fig. 4.

The failure of the pats to remain on the glass or the cracking of the glass to which the pats are attached does not necessarily indicate unsoundness.



COPPER BOILER

To be made of sheet copper weighing 22 oz. per sq. ft., tinned inside. All seams to be lapped where possible. Hard solder only to be used.

Shelf to be made of $\frac{1}{16}$ galvanized iron wire formed on a rim piece of ¼ galvanized iron wire. Size of mesh ½

FIG. 3.—APPARATUS FOR MAKING SOUNDNESS TEST OF CEMENT.

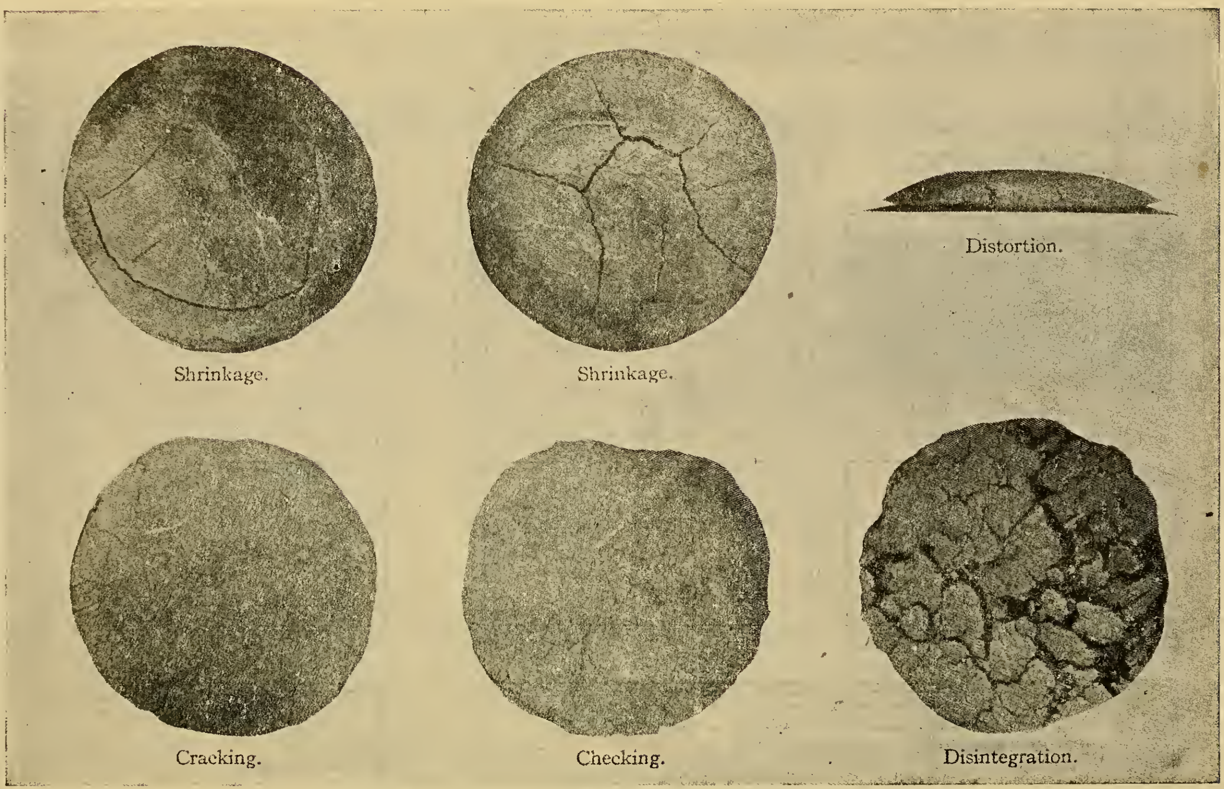
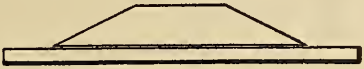
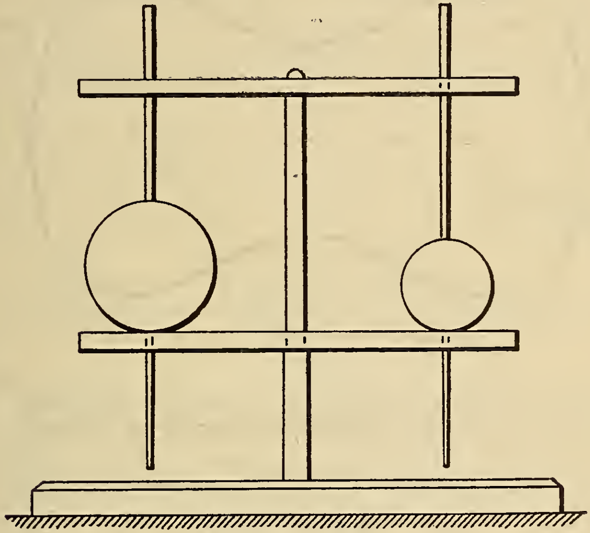


FIG. 4.—TYPICAL FAILURES IN SOUNDNESS TEST.

stored in a moist closet. Care shall be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point may increase the penetration. The time of setting is affected not only by the percentage and temperature of the water used and the amount of kneading the paste receives, but by the temperature and humidity of the air, and its determination is therefore only approximate.



(*a*) Pat with Top Surface Flattened for Determining Time of Setting by Gillmore Method.



(*b*) Gillmore Needles.

Fig. 5.—Gillmore Needles.

Gillmore Needles.

49. The time of setting shall be determined by the Gillmore needles. The Gillmore needles should preferably be mounted as shown in Fig. 5 (*b*).

Gillmore Method.

50. The time of setting shall be determined as follows: A pat of neat cement paste about 3 in. in diameter and ½ in. in thickness with a flat top (Fig. 5 (*a*)), mixed to a normal consistency, shall be kept in moist air at a temperature maintained as nearly as practicable at 21 de-

grees Centigrade (70 degrees Fahrenheit). The cement shall be considered to have acquired its initial set when the pat will bear, without appreciable indentation, the Gillmore needle 1/12 in. in diameter, loaded to weigh ¼ lb. The final set has been acquired when the pat will bear without appreciable indentation the Gillmore needle 1/24 in. in diameter, loaded to weigh 1 lb. In making the test, the needles shall be held in a vertical position and applied lightly to the surface of the pat.

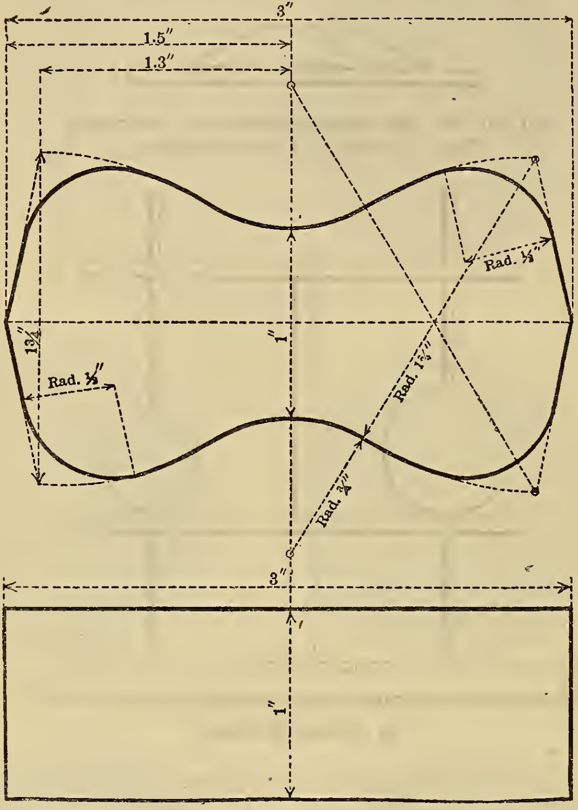


Fig. 6.—Details for Briquette.

(XIV) Tension Tests.

Form of Test Piece.

51. The form of test piece shown in Fig. 6 shall be used. The molds shall be made of non-corroding metal and have sufficient material in the sides to prevent spreading during molding. Gang molds when used shall be of the type shown in Fig. 7. Molds shall be wiped with an oily cloth before using.

Standard Sand.

52. The sand to be used shall be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve and retained on a No. 30 sieve. This sand may be obtained from the Ottawa Silica Company, at a cost of two cents per pound, f. o. b. cars, Ottawa, Ill.

53. This sand, having passed the No. 20 sieve, shall be considered standard when not more than 5 g. pass the No. 30 sieve after one minute continuous sieving of a 500-g. sample.

54. The sieves shall conform to the following specifications:

The No. 20 sieve shall have between 19.5 and 20.5 wires per whole inch of the warp wires and between 19 and 21 wires per whole inch of the shoot wires. The diameter of the wire should be 0.0165-in. and the average diameter shall not be outside the limits of 0.0160 and 0.0170-in.

The No. 30 sieve shall have between 29.5 and 30.5 wires per whole inch of the warp wires and between 28.5 and 31.5 wires per whole inch of the shoot wires. The diameter of the wires should be 0.0110-in. and the average diameter shall not be outside the limits 0.0105 to 0.115-in.

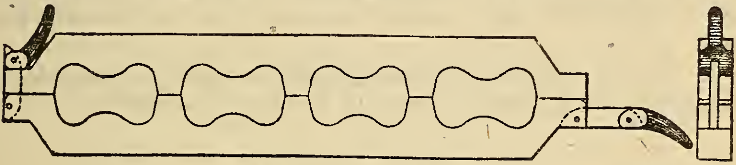


Fig. 7.—Gang Mold.

Molding.

55. Immediately after mixing, the standard mortar shall be placed in the molds, pressed in firmly with the thumbs and smoothed off with a trowel without ramming. Additional mortar shall be heaped above the mold and smoothed off with a trowel; the trowel shall be drawn over the mold in such a manner as to exert a moderate pressure on the material. The mold shall then be turned over and the operation of heaping, thumbing and smoothing off repeated.

Testing.

56. Tests shall be made with any standard machine. The briquettes shall be tested as soon as they are removed from the water. The bearing surfaces of the clips and briquettes shall be free from grains of sand or dirt. The briquettes shall be carefully centered and the load applied continuously at the rate of 600 lb. per minute.

57. Testing machines should be frequently calibrated in order to determine their accuracy.

Faulty Briquettes.

58. Briquettes that are manifestly faulty, or which give strengths differing more than 15 per cent. from the average value of all test pieces made from the same sample and broken at the same period, shall not be considered in determining the tensile strength.

(XV) Storage of Test Pieces.

Apparatus.

59. The moist closet may consist of a soapstone, slate or concrete box or a wooden box lined with metal. If a wooden box is used, the interior should be covered with felt or broad wicking kept wet. The bottom of the moist closet should be covered with water. The interior of the closet should be provided with non-absorbent shelves on which to place the test pieces, the shelves being so arranged that they may be withdrawn readily.

Methods.

60. Unless otherwise specified, all test pieces, immediately after molding, shall be placed in the moist closet for from 20 to 24 hours.

61. The briquettes shall be kept in molds on glass plates in the moist closet for at least 20 hours. After 24 hours in moist air the briquettes shall be immersed in clean water in storage tanks of non-corroding material.

62. The air and water shall be maintained as nearly as practicable at a temperature of 21 degrees Centigrade, 70 degrees Fahrenheit.

[3]SPECIFICATIONS FOR NATURAL CEMENT.

Definition.

1. Natural cement is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

(I) Physical Properties.

Specific Gravity.

2. The specific gravity of the cement, thoroughly dried at 100 degrees Cent., shall not be less than 2.8.

Fineness.

3. The residue on a standard No. 100 sieve shall not exceed 10 per cent., and on a standard No. 200 sieve shall not exceed 30 per cent. by weight.

Soundness.

4. Pats of neat cement about 3 in. in diameter, ½ in. thick at center, tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(*a*) A pat shall then be kept in air at normal temperature.

(*b*) Another pat shall be kept in water maintained as near 70 degrees Fahrenheit as practicable.

---

[3] Adopted, Vol. 18, 1917, pp. 904, 1565.

These pats shall be observed at intervals for at least 28 days, and, to satisfactorily pass the tests, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Time of Setting.

5. The cement shall not develop initial set in less than 10 minutes, using Vicat needle. Final set shall be attained in not less than 30 minutes nor more than 3 hours, using the Vicat needle.

Tensile Strength.

6. The minimum requirements for tensile strength for briquettes 1 sq. in. in cross-section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

Neat Cement.

Age	*Strength*
24 hours in moist air	75 lb.
7 days (1 day in moist air, 6 days in water)	150 lb.
28 days (1 day in moist air, 27 days in water)	250 lb.

One Part Cement, Three Parts Standard Ottawa Sand.

7 days (1 day in moist air, 6 days in water)	50 lb.
28 days (1 day in moist air, 27 days in water)	125 lb.

(II) PACKAGES, MARKING AND STORAGE.

Packages and Marking.

7. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon. A bag shall contain 94 lb. net. A barrel shall contain 282 lb. net.

Storage.

8. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building, which will protect the cement from dampness.

(III) INSPECTION.

Inspection.

9. (*a*) Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test.

(*b*) The cement shall be tested in accordance with the methods contained in the Standard Specifications and Tests for Portland Cement.

(IV) REJECTION.

Rejection.

10. The cement may be rejected if it fails to meet any of the requirements of these specifications.

11. Cement failing to meet the 7-day requirements may be held awaiting the results of the 28-day tests before rejection.

[4]MASONRY SPECIFICATIONS.

It is recommended that railway companies prepare and use specifications complete in themselves for all kinds of masonry, in such form that they may be attached to and form part of specifications and contracts for other railway construction when desirable.

[5]SPECIFICATIONS FOR STONE MASONRY.

GENERAL.

Standard Specifications.

1. The requirements for cement and concrete shall be those adopted by the American Railway Engineering Association.

Engineer Defined.

2. Where the term "Engineer" is used in these specifications, it refers to the Engineer actually in charge of the work.

GENERAL REQUIREMENTS.

Stone.

3. Stone shall be of the kinds designated and shall be hard and durable, of approved quality and shape, free from seams, or other imperfections. Unseasoned stone shall not be used where liable to injury by frost.

Dressing.

4. Dressing shall be the best of the kind specified.

5. Beds and joints or builds shall be square with each other, and dressed true and out of wind. Hollow beds shall not be permitted.

6. Stone shall be dressed for laying on the natural bed. In all cases the bed shall not be less than the rise.

---

[4] Adopted, Vol. 3, 1902, pp. 310, 348.

[5] Adopted, Vol. 7, 1906; pp. 581-587, 602-604, 606-622; Vol. 8, p. 634; Vol. 9, 1908, pp. 650-655, 659; Vol. 12, Part 1, 1911, pp. 478, 579.

7. Marginal drafts shall be neat and accurate.

8. Pitching shall be done to true lines and exact batter.

Mortar.

9. Mortar shall be mixed in a suitable box, or in a machine mixer, preferably of the batch type, and shall be kept free from foreign matter. The size of the batch and the proportions and the consistency shall be as directed by the Engineer. When mixed by hand the sand and cement shall be mixed dry, the requisite amount of water then added and the mixing continued until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

Laying.

10. The arrangement of courses and bond shall be as indicated on the drawings, or as directed by the Engineer. Stone shall be laid to exact lines and levels, to give the required bond and thickness of mortar in beds and joints.

11. Stone shall be cleansed and dampened before laying.

12. Stone shall be well bonded, laid on its natural bed and solidly settled into place in a full bed of mortar.

13. Stone shall not be dropped or slid over the wall, but shall be placed without jarring stone already laid.

14. Heavy hammering shall not be allowed on the wall after a course is laid.

15. Stone becoming loose after the mortar is set shall be relaid with fresh mortar.

16. Stone shall not be laid in freezing weather, unless directed by the Engineer. If laid, it shall be freed from ice, snow or frost by warming. The sand and water used in the mortar shall be heated.

17. With precaution, a brine may be substituted for the heating of the mortar. The brine shall consist of one pound of salt to eighteen gallons of water, when the temperature is 32 degrees Fahrenheit; for every degree of temperature below 32 degrees Fahrenheit, one ounce of salt shall be added.

Pointing.

18. Before the mortar has set in beds and joints, it shall be removed to a depth of not less than one inch. Pointing shall not be done until the wall is complete and mortar set; nor when frost is in the stone.

19. Mortar for pointing shall consist of equal parts of sand, sieved to meet the requirements, and Portland cement. In pointing, the joints

shall be wet, and filled with mortar, pounded in with a "set-in" or calking tool and finished with a beading tool the width of a joint, used with a straight-edge.

Bridge and Retaining Wall Masonry, Ashlar Stone.

20. The stone shall be large and well proportioned. Courses shall not be less than 14 inches or more than 30 inches thick, thickness of courses to diminish regularly from bottom to top.

Dressing.

21. Beds and joints or builds of face stone shall be fine-pointed, so that the mortar layer should not be more than ½-inch thick when the stone is laid.

22. Joints in face stone shall be full to the square for a depth equal to at least one-half the height of the course, but in no case less than 12 inches.

Face or Surface.

23. Exposed surfaces of the face stone shall be rock-faced, with edges pitched to the true lines and exact batter. The face shall not project more than 3 inches beyond the pitch line.

24. Chisel drafts 1½ inches wide shall be cut at exterior corners.

25. Holes for stone hooks shall not be permitted to show in exposed surfaces. Stone shall be handled with clamps, keys, lewis or dowels.

Stretchers.

26. Stretchers shall not be less than 4 feet long with at least one and a quarter times as much bed as thickness of course.

Headers.

27. Headers shall not be less than 4 feet long; shall occupy one-fifth of face of wall; shall not be less than 18 inches wide in face; and, where the course is more than 18 inches high, width of face shall not be less than height of course.

28. Headers shall hold in heart of wall the same size shown in face, so arranged that a header in a superior course shall not be laid over a joint, and a joint shall not occur over a header; the same disposition shall occur in back of wall.

29. Headers in face and back of wall shall interlock when thickness of wall will admit.

30. Where the wall is 3 feet thick or less, the face stone shall pass entirely through. Backing shall not be permitted.

Backing.

*31-a. Backing shall be large, well-shaped stone, roughly bedded and jointed; bed joints shall not exceed 1 inch. At least one-half of the backing stone shall be of same size and character as the face stone and with parallel ends. The vertical joints in back of wall shall not exceed 2 inches. The interior vertical joints shall not exceed 6 inches.

Voids shall be thoroughly filled with *concrete.*
spalls, fully bedded in cement mortar.

*31-b. Backing shall be of *concrete.*
headers and stretchers, as specified in paragraphs 26 and 27, and heart of wall filled with concrete.

32. Where the wall will not admit of such arrangement, stone and less than four (4) ft. long shall be placed transversely in heart of wall to bond the opposite sides.

33. Where stone is backed with two courses, neither course shall be less than eight (8) in. thick.

Bond.

34. Bond of stone in face, back and heart of wall shall not be less than 12 inches. Backing shall be laid to break joints with the face stone and with one another.

Coping.

35. Coping stone shall be full size throughout, of dimensions indicated on the drawings.

36. Beds, joints and top shall be fine-pointed.

37. Location of joints shall be determined by the position of the bed plates, as indicated on the drawings.

Locks.

38. Where required, coping stone, stone in the wings of abutments, and stone on piers, shall be secured together with iron cramps or dowels, to the position indicated on the drawings.

BRIDGE AND RETAINING WALL MASONRY—RUBBLE STONE.

39. The stone shall be roughly squared, and laid in irregular courses. Beds shall be parallel, roughly dressed, and the stone laid horizontal to the wall. Face joints shall not be more than 1 inch thick. Bottom stone shall be large, selected flat stone.

---

*Paragraphs 31-a and 31-b are so arranged that either may be eliminated according to requirements. Optional clauses printed in italics.

40. The wall shall be compactly laid, having at least one-fifth the surface of back and face headers arranged to interlock, having all voids in the heart of the wall thoroughly filled with *concrete.*
suitable stones and spalls, *fully bedded in cement mortar.*

ARCH MASONRY, ASHLAR STONE.

41. Voussoirs shall be full size throughout and dressed true to templet, and shall have bond not less than thickness of stone.

Dressing.

42. Joints of voussoirs and intrados shall be fine-pointed. Mortar joints shall not exceed ⅜-inch.

Face or Surface.

43. Exposed surface of the ring stone shall be *smooth.*
rock faced, with a marginal draft.

44. Number of courses and depth of voussoirs shall be indicated on the drawings.

45. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

46. Backing shall consist of *concrete.*
large stone, shaped to fit the arch bonded to the spandrel and laid in full bed of mortar.

47. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material.

48. Centers shall not be struck until directed by the Engineer.

Bench Walls, Piers, Spandrels, etc.

49. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Ashlar Stone.

ARCH MASONRY—RUBBLE STONE.

Dressing.

50. Voussoirs shall be full size throughout, and shall have bond not less than thickness of voussoirs.

51. Beds shall be roughly dressed to bring them to radial planes.

52. Mortar joints shall not exceed 1 inch.

Face or Surface.

53. Exposed surfaces of ring stone shall be rock-faced, and edges pitched to true lines.

54. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

55. Backing shall consist of *concrete.*
large stone, shaped to fit the arch, bonded to the spandrel, and laid in full bed of mortar.

56. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material. (For information on Waterproofing Masonry, see page 292.)

57. Centers shall not be struck until directed by the Engineer.

Bench Walls, Piers, Spandrels, etc.

58. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Rubble Stone.

CULVERT MASONRY.

59. Culvert Masonry shall be laid in cement mortar. Character of stone and quality of work shall be the same as specified for Bridge and Retaining Wall Masonry, Rubble Stone.

Side Walls.

60. One-half the top stone of the side walls shall extend entirely across the wall.

Cover Stones.

61. Covering stone shall be sound and strong, at least 12 inches thick, or as indicated on the drawings. They shall be roughly dressed to make close joints with each other, and lap their entire width at least 12 inches over the side walls. They shall be doubled under high embankments, as indicated on the drawings.

End Walls, Coping.

62. End walls shall be covered with suitable coping, as indicated on the drawings.

DRY MASONRY.

63. Dry Masonry shall include dry retaining walls and slope walls.

Retaining Walls.

64. Retaining Walls and Dry Masonry shall include all walls in which rubble stone laid without mortar is used for retaining embankments or for similar purposes.

Dressing.

65. Flat stone at least twice as wide as thick shall be used. Beds and joints shall be roughly dressed square to each other and to face of stone.

66. Joints shall not exceed ¾-inch.

Disposition of Stone.

67. Stone of different sizes shall be evenly distributed over entire face of wall, generally keeping the larger stone in lower part of wall.

68. The work shall be well bonded, and shall present a reasonably true and smooth surface, free from holes or projections.

Slope Walls.

69. Slope walls shall be built of such thickness and slope as directed by the Engineer. Stone used in this construction must reach entirely through the wall. Stone shall be placed at right angles to the slopes. The wall shall be built simultaneously with the embankment which it is to protect.

[6]SPECIFICATIONS FOR CONCRETE, PLAIN AND REINFORCED.

(I) MATERIAL.

Cement.

1. The cement shall meet the requirements of the American Railway Engineering Association's "Specifications for Portland Cement." It shall be stored in a weather-tight structure with the floor raised not less than one foot from the ground in such a manner as to permit easy access for proper inspection and identification of each shipment. Cement that has hardened or partially set shall not be used.

Fine Aggregate.

2. (a) The fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry, a screen having holes one-quarter (¼) inch in diameter. Not more than twenty-five (25) per cent. by weight shall pass a No. 50 sieve, and not more than six (6) per cent. a No. 100 sieve when screened dry, nor more than ten (10) per cent. dry weight shall pass a No. 100 sieve when washed on the sieve with a stream of water. It shall be clean and free from soft particles, mica, lumps of clay, loam or organic matter.

---

[6] Adopted, Vol. 21, 1920 pp. 87, 1355.

(b) The fine aggregate shall be of such quality that mortar briquettes made of one (1) part of Portland Cement and three (3) parts of the fine aggregate by weight shall show a tensile strength, after an age of seven (7) days, not less than the strength of briquettes of the same age, made of mortar of the same consistency in the proportion of one (1) part of the same cement to three (3) parts of standard Ottawa Sand.

Coarse Aggregate.

3. The coarse aggregate shall consist of gravel or crushed stone, which, unless otherwise specified or called for on the plans, shall, for plain mass concrete, pass a screen having holes two and one-quarter (2¼) inches in diameter, and for reinforced concrete a screen having holes one and one-quarter (1¼) inches in diameter; and be retained on a screen having holes one-fourth (¼) inch in diameter, and shall be graded in size from the smallest to the largest particles. It shall be clean, hard, durable and free from all deleterious matter; coarse aggregate containing dust, soft or elongated particles shall not be used.

Stone for Rubble or Cyclopean Concrete.

4. These stones shall be of good quality, clean, dense and hard, without seams and having sharp edges. They shall not be smaller than of a size known as "one-man stone."

Slag.

5. Provided the contract specifically permits the use of crushed slag as a coarse aggregate, it shall be air cooled, blast furnace slag, conforming to all the requirements for coarse aggregate specified in Paragraph 3. The crushed slag shall weigh not less than seventy (70) lb. per cubic foot, and shall be obtained only from such banks as have the approval of the Engineer. All slag used shall have seasoned in the bank for a period not less than one (1) year, unless in the opinion of the Engineer a shorter period is sufficient.

Water.

6. The water shall be free from oil, acid and injurious amounts of vegetable matter, alkalies or other salts.

Steel Reinforcement.

7. (a) All structural steel shapes used for reinforcing shall conform to the requirements of the American Railway Engineering Association's "Specifications for Steel Railway Bridges."

(b) All steel rods or bars used for reinforcing shall conform to the requirements of the American Railway Engineering Association's "Specifications for Billet-Steel Concrete Reinforcement Bars."

(II) PROPORTIONING.

Unit of Measure.

8. The unit of measure shall be the cubic foot. Ninety-four (94) lb. (one (1) sack or one-fourth (¼) barrel) of cement shall be assumed as one (1) cubic foot.

Proportions.

9. (a) The proportions of the materials shall be in accordance with the plans, or detailed specifications, or schedule governing the work. When not otherwise specified, the proportions by volume shall be as follows: (See 8, 10.)

Class.	*Use.*	*Cement.*	*Fine Aggregate.*	*Coarse Aggregate.*
A	Reinforced concrete—Concrete deposited under water	1	2	4
B	Mass concrete in forms	1	2½	5
C	Foundation	1	3	6

(b) Rubble or cyclopean concrete, when permitted by the contract, shall be either Class "B" or Class "C" concrete, having embedded in it large stones.

(c) For any given class of concrete, the relative proportion of cement to fine aggregate shall not be modified. The relative proportion of fine to coarse aggregate shall be modified, if necessary, during the progress of the work, so as to obtain the maximum density. (See 9a.)

Measuring Proportions.

10. The various ingredients, including the water, shall be measured separately, and the methods of measurement shall be such as to invariably secure the proper proportions. The fine and coarse aggregate shall be measured loosely as thrown into the measuring receptacle. (See 8, 9a.)

Consistency.

11. The quantity of water used in mixing shall be the least amount that will produce a plastic or workable mixture which can be worked into the forms and around the reinforcement. Under no circumstances shall the consistency of the concrete be such as to permit a separation of the coarse aggregate from the mortar in handling. An excess of water will not be permitted, as it seriously affects the strength of the concrete and any batch containing such an excess will be rejected.

Premixed Aggregate.

12. (a) Provided the contract specifically permits, premixed aggregate may be used instead of separate fine and coarse aggregates. Frequent tests shall be made to determine the relative proportions of fine and coarse aggregates, and if these proportions are unsatisfactory to the Engineer, or so irregular as to make it impracticable to secure a properly proportioned concrete, he may reject the material, or require that it be screened and used as separate fine and coarse aggregates.

(b) The proportion of the cement to the fine aggregate shall at no time be less than that specified for the classes of concrete where separate aggregates are used (See 9a.)

(III) FORMS.

Materials.

13 (a) The forms shall be of wood or metal, and shall conform to the shape, lines and dimensions of the concrete as called for on the plans. Form lumber used against the concrete shall be dressed on one side and both edges, to a uniform thickness and width, and shall be sound and free of loose knots.

(b) For all exposed edges, corners or other projections of the concrete, suitable moldings or bevels shall be placed in the angles of the forms to round or bevel the edges of the concrete.

Workmanship.

14. (a) The forms shall be well built, substantial and unyielding, and made sufficiently tight to prevent leakage of mortar and voids in the concrete. They shall be properly braced or tied together by rods, bolts or wires. Metal braces or ties shall be so arranged that when the forms are removed, no metal shall be within one (1) inch of the face of the finished work.

(b) The face forms shall be securely fastened to the studding or uprights in horizontal lines.

(c) Any irregularities in the forms which may mar the exposed surface of the concrete shall be removed or filled.

Inspection.

15. Where necessary, temporary openings shall be provided at the base of the forms to facilitate cleaning and inspection directly before placing concrete. (See 23b.)

Oiling.

16. The inside of the forms shall generally be coated with raw paraffin or other non-staining mineral oil; or thoroughly wet with water, except in freezing weather. (See 23b.)

Removal of Forms.

17. The forms shall not be removed until authorized by the Engineer.

(IV) REINFORCEMENT.

Placing Reinforcement.

18. Reinforcing steel shall be cleaned of all mill and rust scales before being placed in the forms. All reinforcement shall be placed in its proper position as required by the plans and securely wired or fastened in place, well in advance of the concreting, and shall be inspected and approved by the Engineer before any concrete is deposited. (See 23b.)

Splicing Reinforcement.

19. Wherever it is necessary to splice the reinforcement otherwise than as shown on the plans, the character of the splice shall be decided

by the Engineer on the basis of safe bond stress and the stress in the reinforcement at the point of splice. Splices shall not be made at points of maximum stress.

(V) Mixing.

Machine Mixing.

20. (a) All concrete shall be mixed by machine (except when under special conditions the Engineer permits otherwise), in a batch mixer of an approved type, equipped with suitable charging hopper, water storage and a water measuring device which can be locked.

(b) The ingredients of the concrete shall be mixed to the required consistency and the mixing continued not less than one and one-half (1½) minutes after all the materials are in the mixer, and before any part of the batch is discharged. The mixer shall be completely emptied before receiving materials for the succeeding batch. The volume of the mixed material used per batch shall not exceed the manufacturers' rated capacity of the drum. (See 11.)

Hand Mixing.

21. When it is permitted to mix by hand, the mixing shall be done on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. The batches shall not exceed one-half (½) cubic yard each. The materials shall be mixed dry until the mixture is of a uniform color, the required amount of water added, and the mixing continued until the batch is of a uniform consistency and character throughout. Hand mixing will not be permitted for concrete deposited under water. (See 11.)

Retempering.

22. The retempering of mortar or concrete which has partially hardened; that is, remixing with or without additional materials or water, will not be permitted.

(VI) Depositing.

General.

23. (a) Before beginning a run of concrete, all hardened concrete or foreign materials shall be completely removed from the inner surfaces of all conveying equipment.

(b) Before depositing any concrete, all debris shall be removed from the space to be occupied by the concrete, all steel reinforcing shall be secured in its proper location, all forms shall be thoroughly wetted except in freezing weather unless they have been previously oiled, and all form work and steel reinforcing shall be inspected and approved by the Engineer. (See 15, 16 and 18.)

Handling.

24. Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible, and by methods of transporting which shall prevent the separation of the ingredients. The concrete shall be deposited directly into the forms as nearly as possible in its final position so as to avoid rehandling. The piling up of concrete material in the forms in such manner as to permit the escape of mortar from the coarse aggregate will not be permitted. Under no circumstances shall concrete that has partially set be deposited in the work. (See 22.)

Compacting.

25. During and after depositing, the concrete shall be compacted by means of a shovel or other suitable tool moved up and down continuously in the concrete until it has all settled into place and water has flushed to the surface. The concrete shall be thoroughly worked around all reinforcing material so as to completely surround and embed the same.

Cold Weather.

26. During cold weather, the concrete at the time it is mixed and deposited in the work shall have a temperature not lower than fifty (50) degrees Fahrenheit, and suitable means shall be provided to maintain this temperature for at least seventy-two (72) hours thereafter, and until the concrete has thoroughly set. The methods of heating materials and protecting the concrete shall be approved by the Engineer. The use of any salt or chemical to prevent freezing will not be permitted.

Depositing on or Against Set Concrete.

27. Before depositing new concrete on or against concrete which has set, the forms shall be retightened against the face of the latter, the surface of the set concrete shall be roughened and thoroughly cleaned of foreign matter and laitance, and saturated with water. The new concrete placed in contact with set or partially set concrete shall contain an excess of mortar to insure bond. To insure this excess of mortar at the juncture of the set and newly deposited concrete on vertical or inclined surfaces, the cleaned and drenched surface of the set concrete shall first be slushed with a coating of mortar, not less than one inch thick, composed of one (1) part cement to two (2) parts fine aggregate, against which the new concrete shall be deposited before this mortar has had time to attain its initial set.

Rubble or Cyclopean Concrete.

28. After each layer of concrete is placed, and before it has taken its initial set, the stones are to be thoroughly bedded in the soft concrete. No stone shall be placed nearer than one (1) foot to any finished surface; nor nearer than six (6) inches to any adjacent stone. After the stones are in place another layer of concrete shall be placed sufficient to cover the stones to a depth of at least six (6) inches.

When stratified stones are used, they shall be laid upon their natural bed. (See 4, 9b.)

(VII) Depositing Concrete Under Water.

General.

29. Concrete shall not be deposited in water without the written consent of the Engineer. A written statement of the methods and plans of equipment to be used shall be submitted to and approved by the Engineer before the work is started. (See 9a, 11, 21.)

Cofferdams.

30. Cofferdams shall be sufficiently tight to prevent any current through the space in which the concrete is to be deposited. Pumping will not be permitted while the concrete is being deposited, nor until it has fully set.

Method.

31. The concrete shall be deposited by such method as will prevent the washing of the cement from the mixture. In no case shall the concrete be allowed to fall through the water.

Tremie.

32. The tremie, where used, shall be about fourteen (14) or sixteen (16) inches in diameter, and made flanged and put together with gaskets. The initial filling of the tremie shall be done in such manner as not to permit the concrete to drop through the water. It shall be kept filled at all times, and the discharge end raised a few inches at a time as the filling progresses. The greatest care shall be used to prevent the charge being lost in moving the tremie about on the surface of the deposited concrete. In case the charge is lost, the tremie must be withdrawn and refilled.

Drop Bottom Bucket.

33. (a) The bucket, where used, shall be of such a type that it cannot be dumped until it rests on the surface upon which the concrete is to be deposited. The frame shall extend below the closed bottom doors so they may open freely downward and outward when tripped. The ends of the bucket shall extend without openings to the bottom of the frame. The top of the bucket shall be open.

(b) The bucket shall be completely filled, and slowly lowered to avoid unnecessary back wash. When discharged the bucket shall be withdrawn slowly until clear of the concrete.

Bagging.

34. The bags, when used, shall be of jute or other coarse cloth. They shall be about two-thirds filled with concrete, and shall be carefully placed by hand in a header and stretcher system so the whole mass is interlocked.

Continuous Operation.

35. Where possible, the concrete shall be deposited continuously from the time the work is started until it is brought above water level or

to the finished surface. The work shall be carried on with sufficient rapidity to insure bonding of the successive layers. The surface of the deposited concrete shall be kept as nearly level as possible.

Laitance.

36. Great care shall be exercised to disturb the concrete as little as possible while it is being deposited, to avoid the formation of laitance. On completing a section of concrete, the laitance shall be entirely removed after the concrete has thoroughly set and before the work is resumed.

(VIII) JOINTS.

General.

37. (a) Instructions given on the plans, in the detailed specifications or schedule governing the work as to location and construction of joints, shall be strictly followed.

(b) When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally, except as hereinafter modified. (See 38a, b, c, d.)

Construction Joints.

38. (a) When necessary to provide construction joints not indicated, or specified, such joints shall be located and formed so as to least impair the strength and appearance of the structure. Where conditions require, the joints shall be reinforced as directed by the Engineer, in order to secure the necessary bond strength.

(b) Horizontal construction joints shall be prepared at the time the work is interrupted by thoroughly roughening the surface and providing keys by embedding stones which project above the surface, or mortises by embedding timbers which shall be removed before the work of placing concrete is resumed.

(c) At all horizontal or vertical construction joints, the surface of the previously deposited concrete shall always be roughened and cleaned of all laitance and foreign material before depositing new concrete. (See 27.)

(d) Where girders, beams and slabs are designed to be monolithic with walls and columns, they shall not be cast until four (4) hours after the completion of the walls or columns in order to permit of shrinkage or settlement. In case the columns are structural steel, encased in concrete or concrete columns having flaring heads, the lapse of time to allow for shrinkage or settlement need not be observed. (See 37b.)

Watertight Joints.

(39) When it is not possible to finish a complete section in one continuous operation, and a watertight joint is required, sheet lead or other metal, not less than six inches wide, and extending the full length of the joint, shall be embedded equally in the two deposits of concrete.

Sliding Joints.

40. Where sliding joints are to be provided, the seat shall be finished with a smooth trowel surface and shall not have the superimposed concrete placed upon it until the previously deposited concrete has thoroughly set. Unless otherwise indicated on the plans, or specified, two thicknesses of building paper shall be placed over the bearing before the superimposed concrete is deposited, in order to make a defined sliding joint.

Expansion Joints.

41. (a) At all expansion joints, the break in the bond between the two sections shall be complete, and shall be insured by the application of petroleum oil, hot coal tar pitch, tarred felt or similar material over the entire joint surface of the first deposited concrete.

(b) No reinforcement shall extend across an expansion joint.

(c) Triangular shaped grooves shall be formed in the exposed surface of the concrete at all expansion joints in walls or abutments.

(d) Where expansion joints are formed between two distinct concrete members, and said joint is exposed, it shall be filled with an elastic joint filler of approved quality.

(IX) SURFACING AND FINISHING.

General.

42. Except where a special surface or finish is required, the surfacing and finishing shall be done in accordance with the requirements specified for a "Spaded Surface." (See 43a, b, c.)

Spaded Surface.

43. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, bars or other suitable tools, so as to bring a surface of mortar against the form. Care shall be taken to remove all air pockets and to prevent voids in the surface.

(b) Except where otherwise directed by the Engineer, face forms shall be removed as soon as the setting of the concrete will permit. (See 17.)

(c) After the removal of the forms, any holes or voids in the surface of the concrete shall be filled with a mortar made of the same proportions of sand and cement as those of the concrete and rubbed smooth and even with the surface with a wooden float. A trowel shall not be used for this purpose. (See 42.)

Top Surfaces.

44. (a) Top surfaces shall generally be "struck" with a straight edge or "floated" after the coarse aggregates have been forced below the surface.

(b) Where "sidewalk finish" is called for on the plans, it shall be made by the spreading of a 1:2 mortar at least three-quarters (¾) inch thick, and floating this to a smooth surface. This finishing coat shall be put on before the concrete has taken its initial set. For a walk, the surface shall be slightly roughened with a special tool or by sweeping with a coarse broom.

Wetting Surfaces.

45. The surfaces of concrete exposed to premature drying shall be kept thoroughly and constantly wetted for a period of at least three (3) days. For wearing surfaces, this period shall be at least ten (10) days.

(X) Special Finishes.

General.

46. (a) In special work where detailed instructions are given on the plan, or in the specifications, as to conveying, depositing, or finishing concrete, the same shall be strictly followed; where a special finish is called for, the same shall be in accordance with the following paragraphs that apply to the finish called for.

(b) The forms shall be made of lumber dressed to a uniform thickness and width, or dressed and matched to a uniform thickness and width, or lumber lined with metal, or metal carefully built to exact dimensions and shape, with close level joints, smooth inside surfaces and sufficiently braced and tied together to be unyielding. The inside surfaces shall be washed just before the concrete is placed. Where the smoothest surface practicable with all wooden forms is desired, the inside surface shall be coated with light paraffin oil, boiled linseed oil, or other approved material.

(c) The whole extent of a surface to be finished shall be built in one continuous operation. Where a continuous operation is not possible, the seam or joint between the concrete placed first and that placed later shall be made watertight, with sheet lead or other metal, embedded equally in the two deposits of concrete or by some other approved method.

(d) The same brand of cement shall be used throughout the whole of any surface or structure.

(e) Where margins, patterns or different finish from the remainder of the surface are required, the forms shall be removed at the proper time to permit these to be laid off and finished in the best manner for the method specified.

(f) All work shall be finished free from streaks, discolorations or other imperfections that impair the appearance or life of the finish.

Rubbed Finish—Carborundum or Cement Bricks.

47. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, or other suitable tools, so as to bring a surface of mortar against the form. Care shall be taken to remove all air pockets and to prevent voids in the surface.

(b) The forms shall be carefully removed from the surface to be finished as early as practicable, all joint marks, projections and inequalities chipped off, and all voids filled with a mortar made of the same proportions of cement and sand as those of the concrete.

(c) These surfaces shall then be thoroughly wet with water, and while wet, rubbed to a smooth uniform finish, with a brick made of one part Portland Cement and two (2) parts or two and one-half (2½) parts sand, or with a No. 3 Carborundum brick followed by a No. 30 or with a No. 24 Carborundum brick, as may be necessary to obtain the desired degree of smoothness.

(d) No mortar or cement shall be applied except to fill distinct voids in the surface. Uneven places shall be smoothed by rubbing down and not by plastering. The surface shall be kept moist and protected from rapid drying for not less than three (3) days. (See 46a, b, c, d, e, f.)

Rubbed Finish—Wooden Floats.

48. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, or other suitable tools, so as to bring a surface of mortar against the form. Especial care shall be taken to remove air pockets and to prevent voids in the surface.

(b) The forms shall be carefully removed from the surface to be finished while the concrete is green, all joint marks, projections and inequalities chipped off, and all voids filled with a mortar made of the same proportions of cement and sand as those of the concrete.

(c) The surfaces shall then be rubbed with soft wood floats, and kept well flushed with water during the rubbing. When the desired finish is obtained, the whole surface shall be thoroughly washed with water.

(d) No mortar or cement shall be applied except to fill distinct holes or cavities. Uneven places shall be smoothed by rubbing down and not by plastering. The surface shall be kept moist and protected from rapid drying for not less than three (3) days. (See 46a, b, c, d, e, f.)

Faced Surfaces.

49. (a) The outside layer of the surface to be finished shall be composed of one (1) part cement and three (3) parts graded aggregate mixed to a stiff mortar. The aggregate shall be crushed to pass a sieve of three-eighths (⅜) inch mesh and be retained on a No. 100 sieve. The cement and the aggregate shall each be measured carefully and accurately for each batch and all batches shall be gaged with the same amount of water and carefully mixed in the same manner and for the same length of time, in order to obtain uniform surfaces.

(b) For vertical surfaces the above surface mixture shall be placed against the forms by skilled workmen (using metal slip plates, where practicable) in a layer not less than one (1) inch thick, as the concrete is deposited, in order that the surface mixture shall form a part of the mass of the concrete. Care shall be taken to remove air pockets and to prevent voids in the surface. For horizontal surfaces, the surface mixture shall be placed as the concrete is deposited and before the concrete has set, and, where possible, troweled or floated to an even surface. (See 46a, b, c, d, e, f.)

Unfaced Surfaces.

50. (a) The surface concrete shall be of the same mixture as specified for the body of the structure. The cement and the aggregate shall be measured carefully and accurately for each batch and all batches shall be gaged with the same amount of water, and carefully mixed in the same manner, and for the same length of time, in order to obtain uniform surfaces.

(b) The concrete shall be spaded vertically against the forms only as much as will remove air pockets and prevent voids, care being taken not to force the coarse aggregate away from the form. (See 46a, b, c, d, e, f.)

Washed or Scrubbed Finish.

51. As soon as the concrete has hardened sufficiently, but while it is still green, the forms shall be carefully removed from the surface to be finished, and all voids filled with the surface mixture. The surface shall then be scrubbed with water and brushes of stiff fiber, or of wire, until the aggregate is sufficiently exposed and projects slightly, but not enough to injure its adhesion in the mass. The whole surface shall then be washed with water until thoroughly clean. If necessary, in order to remove the film of cement from the surface of the exposed aggregate or to better bring out the color, the surface shall be washed with a solution of one (1) part commercial hydrochloric acid and two and one-half (2½) parts water, applied with brushes of stiff vegetable fiber. All traces of the acid shall be immediately and completely removed by washing with water. After the final washing, the surface shall be kept moist and protected from rapid drying for not less than three (3) days. (See 46a, b, c, d, e, f.)

Acid Treated Finish.

52. (a) After the forms are removed all voids shall be filled with the surface mixture. The surface to be finished shall then be washed with commercial hydrochloric or nitric acid, diluted with water according to the age and hardness of the concrete. The strength of the solution shall be determined by trial on the work, and shall only be such that the bond of the cement will be readily broken to the required depth. The solution shall be applied with stiff vegetable fiber brushes, and the surface scrubbed until the aggregate is exposed to the desired amount.

(b) As soon as the desired surface is obtained, all traces of the acid shall be quickly and completely washed off with water to prevent its further action, and the permanent discoloration of the surface. (See 46a, b, c, d, e, f.)

Note—For concrete that is but a few days old, a dilution of one (1) part acid to six (6) parts water may be sufficient. For concrete two (2) weeks old, a dilution of only two (2) or three (3) parts may be necessary.

Sand Blast Finish.

53. After the forms are removed, all voids shall be filled with the surface mixture, and left to harden as long as possible. All joint marks and projections shall be chipped off. The outside mortar shall then be cut away with a sand-blast, using a hard sand with angular grains. The nozzle shall not be larger than one-eighth (⅛) inch diameter, and shall be held close to the surface. Care shall be taken to cut all the surface to a uniform depth. The work shall preferably be done between ten (10) and fourteen (14) days after the concrete is placed. (See 46a, b, c, d, e, f.)

Tooled Finish.

54. (a) The proportions of cement and fine aggregate shall be such as to produce a mortar of a density or hardness as nearly equal to that of the coarse aggregate as possible.

(b) After the forms are removed, all voids shall be filled with the surface mixture and left to harden as long as possible. After the concrete has set, and become hard, the surface to be finished shall be dressed (with a bush hammer of three (3) to six (6) cuts per inch, a crandall, a toothed pick, a pneumatic or an electric or other desired tool) to a uniform depth and finish. Care shall be taken to make all margins and patterns straight and true. (See 46a, b, c, d, e, f.)

[7]SPECIFICATIONS FOR BILLET-STEEL CONCRETE REINFORCEMENT BARS.

Material Covered.

1. (a) These specifications cover two classes of billet-steel concrete reinforcement bars, namely: plain and deformed.

(b) Plain and deformed bars are of three grades, namely: structural-steel, intermediate and hard.

(c) Twisted bars will not be accepted under these specifications.

Basis of Purchase.

2. The structural-steel grade shall be used unless otherwise specified.

(I) MANUFACTURE.

Process.

3. (a) The steel shall be made by the Open-Hearth process.

(b) The bars shall be rolled from new billets. No rerolled material will be accepted.

(II) CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The steel shall conform to the following requirement as to chemical composition:

Phosphorus...............not over .05 per cent.

---

[7] Adopted, Vol. 21, 1920, pp. 99, 1361.

Ladle Analyses.

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 4.

Check Analyses.

6. Analyses may be made by the purchaser from finished bars representing each melt of Open-Hearth steel. The phosphorus content thus determined shall not exceed that specified in Section 4 by more than 25 per cent.

(III) PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

7. (a) The bars shall conform to the following requirements as to tensile properties:

TENSILE PROPERTIES

Properties Considered	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Tensile strength lb. per sq. in.	55,000 to 70,000	70,000 to 85,000	80,000 min.	55,000 to 70,000	70,000 to 85,000	80,000 min.
Yield point, min., lb. per sq. in.	33,000	40,000	50,000	33,000	40,000	50,000
Elongation in 8-in. min. %....	1,400,000 *a* Tens. Str.	1,300,000 *a* Tens. Str.	1,200,000 *a* Tens. Str.	1,250,000 *a* Tens. Str.	1,125,000 *a* Tens. Str.	1,000,000 *a* Tens. Str.

a See Section 8.

(b) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation.

8. (a) For plain and deformed bars over ¾-in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 7 (a) shall be made for each increase of ⅛-in. in thickness or diameter above ¾-in.

(b) For plain and deformed bars under 7/16-in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 7 (a) shall be made for each decrease of 1/16-in. in thickness or diameter below 7/16-in.

Bend Tests.

9. The test specimen shall bend cold around a pin without cracking on the outside of the bent portion, as follows:

Bend-Test Requirements

Thickness or Diameter of Bar	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Under ¾ inch...	180 deg. d=t	180 deg. d=2t	180 deg. d=3t	180 deg. d=t	180 deg. d=3t	180 deg. d=4t
¾ inch or over..	180 deg. d=t	90 deg. d=2t	90 deg. d=3t	180 deg. d=2t	90 deg. d=3t	90 deg. d=4t

Explanatory Note: d= the diameter of pin about which the specimen is bent.
t= the thickness or diameter of the specimen.

Test Specimens.

10. Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled.

Number of Tests.

11. (a) One tension and one bend test shall be made from each melt, except that if material from one melt differs ⅜-in. or more in thickness or diameter, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (a), and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(IV) Permissible Variations in Weight.

Permissible Variations.

12. The weight of any lot of bars shall not vary more than 5 per cent. from the theoretical weight of that lot.

(V) Finish.

Finish.

13. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

(VI) Inspection and Rejection.

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

16. Samples tested in accordance with Section 6, which represent rejected bars, shall be preserved for two weeks, from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

[5]SPECIFICATIONS FOR CONSTRUCTING PRE-MOLDED CONCRETE PILES.

1. Piles shall be made in accordance with the dimensions shown on the drawings.

2. The workmanship and materials shall be in accordance with the Specifications for Concrete, Plain and Reinforced, of the American Railway Engineering Association, with the following modifications:

Aggregates.

3. The coarse aggregate shall consist of material such as crushed stone or gravel varying in size from one-fourth (¼) inch to three-fourths (¾) inch.

Proportions.

4. The proportions of the concrete shall be one part cement, two parts fine aggregate and four parts coarse aggregate.

Forms.

5. The forms shall be supported vertically or on skids sufficiently close to prevent sagging of forms.

Reinforcement.

6. The longitudinal and transverse reinforcement shall be assembled and securely wired together in accordance with plan before being placed in form. Care shall be taken to maintain the proper position of reinforcing unit in the form until concrete has been placed and compacted.

Freezing Weather.

7. In freezing weather concrete materials shall be stored, and mixing and placing shall be done in a building maintained at a temperature of not less than 40 degrees Fahrenheit. Piles shall not be exposed to a lower temperature for at least 10 days after forms are removed.

---

[5] Adopted, Vol. 19, 1918, pp. 725, 1229.

Curing.

8. Where ordinary method of sheltered curing is employed, piles shall be seasoned for a period of not less than three days before being moved on the skids and not less than twenty-eight days before handling and moving to the site or driving. No method of accelerated seasoning shall be used until approved by the Engineer.

Marking.

9. Each pile shall be stamped or marked with the date of its manufacture.

Handling.

10. Piles shall be handled carefully, avoiding any dropping or heavy jarring while in horizontal positions.

[9]SPECIFICATIONS FOR DRIVING PRE-MOLDED CONCRETE PILES.

1. Piles shall be protected while being driven with an approved cushion cap.

2. The driving or jetting of piles shall be governed by "Pile Driving —Principles of Practice," given in the Specifications for Workmanship for Pile and Frame Trestles in the Manual of the Association.

3. In driving, a steam hammer shall be used unless otherwise specified by the Engineer. Where a drop hammer is permitted, a heavy hammer with a short drop shall be used.

4. Any pile injured in driving or driven out of place shall be either replaced by a new pile or pulled and re-driven, as the case may require.

5. On sloping ground, and where necessary, a suitable hole shall be dug at the location of each pile, sufficiently deep to hold the pile in proper position for the first few blows.

6. Before driving, the piles shall be carefully located and set to the line called for on the plan, and the pile driver leads held in proper position by means of guy lines. Unless otherwise called for on the plans, piles shall be driven as nearly as possible in a plumb position. Any pile out of plumb more than one-half inch per foot shall be pulled and re-driven if so required by the Engineer.

7. Reasonable efforts shall be made to drive the concrete piles to plan cut-off, the lengths of the piles having been determined by borings or test piles. Driving will be continued until this point is reached or until the following rate of penetration is secured, as specified by Engineer. (Cases where driving is through soft soil to hard bottom or rock excepted.)

---

[9] Adopted, Vol. 19, 1918, pp. 728, 1229.

8. When driving is interrupted before final penetration is reached record for degree of penetration shall not be taken until after at least two (2) inches of penetration has been obtained. When necessary to obtain the required penetration, piles may be driven not to exceed four (4) inches below plan cut-off.

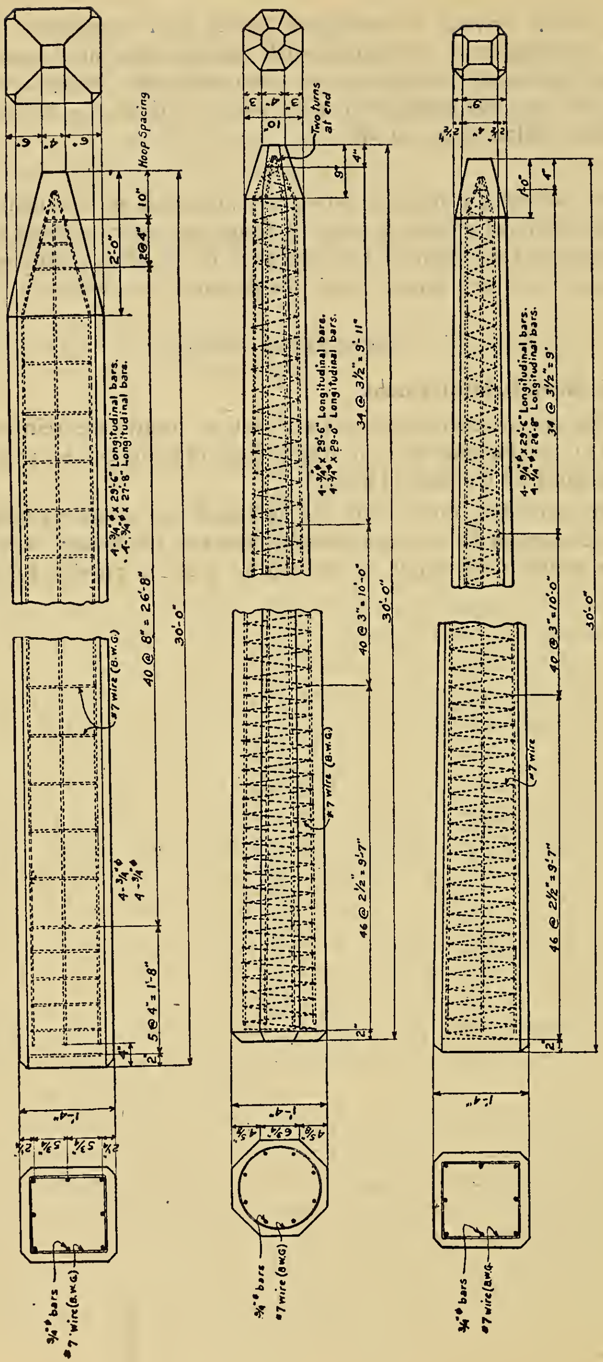
The following plans and details are presented as information drawn from the study of a large number of plans and records, which may serve as a guide in the design of concrete piles for ordinary conditions. Piles which are to act as columns should be designed as columns.

Explanatory Notes.

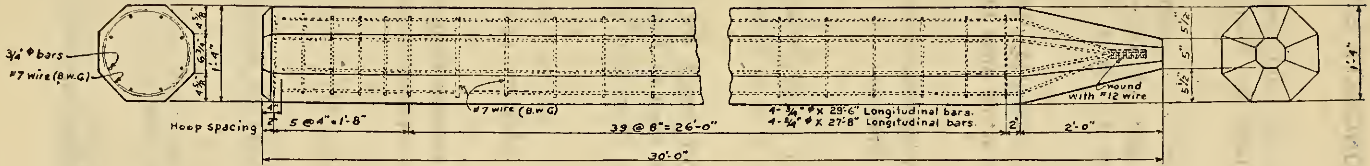
Longitudinal Reinforcement.

Piles not exceeding thirty (30) feet in length are reinforced with eight (8) longitudinal bars of which four (4) are cut so as to stop at the beginning of the tapered point.

Piles exceeding thirty (30) feet in length are shown as having additional reinforcing bars placed midway between the longer bars throughout the middle third length of the pile in order to provide for handling.



TYPICAL CONCRETE PILE SECTIONS.



Length of pile	Longitudinal Reinforcement		Transverse Reinforcement	
	Detail	Weight per foot.	Hoop	Spiral
20' to 25'	8-5/8"φ Bars.	8.34 lbs.	Six spaces from butt end at four (4) inches center to center; balance at eight (8) inches center to center, or other equivalent section of steel per lineal foot of pile.	Wire wound spirally around longitudinal bars with spacing as follows:- 1/3 Length of pile, Butt end 2 1/2". 1/3 " " " , Middle Section 3". 1/3 Length of pile, point end 3 1/2".
26' to 30'	8-3/4"φ Bars.	12.02 lbs		
31' to 35'	8-3/4"φ Bars.	14.78 lbs.		
	* 8-5/8"φ Bars			
36' to 40'	8-7/8"φ Bars*	20.32 lbs.		
	* 8-3/4"φ Bars		Note. Round or square bars of equivalent section may be used. Hoop or spirally wound transverse reinforcement may be used in all types of piles.	
* Placed in middle third of length				

[10]DESIGNS OF REINFORCED CONCRETE STRUCTURES.

Materials.

(1) The materials and workmanship for reinforced concrete should meet the requirements of the "Specifications for Plain and Reinforced Concrete."

The concrete recommended for general use is a mixture of one part of cement, two parts of fine and four parts of coarse aggregates. A richer mixture will be found advantageous for special conditions.

Dead Load.

(2) The dead load is to include the estimated weight of the structure and all other fixed loads and forces acting upon the structure.

Live Load.

(3) The live load is to include all variable and moving loads or forces acting upon the structure in any direction.

Impact. Span Lengths.

(4) As the working stresses herein recommended are for static loads, the dynamic effect of moving loads is to be added to the live load stresses.*

(5) For calculating stresses the span length for bending moment for beams and slabs is to be taken as the distance from center to center of the supports, but not to exceed the clear span plus the depth of beam or slab.

Internal Stresses.

(6) The internal stresses are to be calculated upon the basis of the following assumptions:

(a) A plane section before bending remains plane after bending.

(b) The distribution of compressive stresses in members subject to bending is rectilinear.

(c) The ratio of the moduli of elasticity of steel and 1:2:4 concrete is assumed 15.

(d) The tensile stresses in the concrete are neglected in calculating the moment of resistance of beams.

---

[10] Adopted, Vol. 11, 1910, pp. 967-969, 1019, 1020.

* The following formula is not recommended by the Committee, but is merely given as an illustration:

$$\text{Impact} = \frac{L}{L+D} L$$

L=Live load stress. D=Dead load stress.

(e) The initial stress in the reinforcement due to contraction or expansion in the concrete is neglected.

(f) The depth of a beam is the distance from the compressive face to the centroid of the tension reinforcement.

(g) The effective depth of a beam at any section is the distance from the centroid of the compressive stresses to the centroid of the tension reinforcement.

(h) The maximum shearing unit stress in beams is the total shear at the section divided by the product of the width of the section and the effective depth at the section considered. This maximum shearing unit stress is to be used in place of the diagonal tension stress in calculations for web stresses.

(i) The bond unit stress is equal to the vertical shear divided by the product of the total perimeter of the reinforcement in the tension side of the beam and the effective depth at the section considered.

(k) For columns in fireproof construction and in hooped columns the outside concrete to a depth of 1½ inches is to be considered as a protective covering and is not to be included in the effective section.

Web Stresses.

*(7) "When the maximum shearing stresses exceed the value allowed for the concrete alone, web reinforcement should be provided to aid in carrying the diagonal tension stresses. This web reinforcement may consist of bent bars, or inclined or vertical members, attached to or looped about the horizontal reinforcement. Where inclined members are used, the connection to the horizontal reinforcement should be such as to insure against slip.

"In the calculation of web reinforcement when the concrete alone is insufficient to take the diagonal tension the concrete may be counted upon as carrying one-third of the shear. The remainder is to be provided for by means of metal reinforcement consisting of bent bars or stirrups, but preferably both. The requisite amount of such reinforcement may be estimated on the assumption that the entire shear on a section, less the amount assumed to be carried by the concrete, is carried by the reinforcement in a length of beam equal to its depth."

Shrinkage and Temperature Reinforcement.

(8) Reinforcement for shrinkage or temperature stresses, in amount generally not less than one-third of 1 per cent., and of a form which

---

* The recommendations regarding web stresses are quoted from a report of the Joint Committee on Concrete and Reinforced Concrete.

will develop a high bond resistance, should be placed and be well distributed near the exposed surface of the concrete.

Working Stresses.

(9) The following recommended working stresses, in pounds per square inch of section, are for use in concrete of such quality as to be capable of developing an average compressive strength of at least 2000 lb. per square inch when tested in cylinders 8 inches in diameter and 16 inches long and 28 days old, under laboratory conditions of manufacture and storage, the mixture being of the same consistency as is used in the field:

Structural steel in tension	14,000
High carbon steel in tension	16,000
Steel in compression, 15 times the compressive stress in the surrounding concrete.	
Concrete in bearing where the surface is at least twice the loaded area	700
Concrete in direct compression, without reinforcement on lengths not exceeding six times the least width	450
Concrete in direct compression with not less than 1 per cent. nor over 4 per cent. longitudinal reinforcement on lengths not exceeding twelve times the least width, provided, the longitudinal reinforcement is held in position by horizontal hoops, or a continuous spiral spaced not more than 6 inches apart	450
Concrete in compression, on extreme fiber in cross bending	750
Concrete in shear, uncombined with tension or compression in the concrete	120
Concrete in shear, where the shearing stress is used as the measure of web stress	40
Note.—The limit of shearing stresses in the concrete, even when thoroughly reinforced for shear and diagonal tension, should not exceed	120
Bond for plain and twisted bars	80
Bond for drawn wire	40
Bond for deformed bars, depending upon form	80-100

[11]METHODS OF DEPOSITING CONCRETE UNDER WATER.

1. In general, where possible, the depositing of concrete under water should be avoided, even if such action results in additional expense and possible delay to the work. There is always uncertainty as to the results obtained, and, where conditions will permit, the additional expense and delay of avoiding it is well warranted.

2. In view of this uncertainty, the need of close supervision by men competent to handle this class of work is of the utmost importance, and concrete should never be deposited under water without experienced supervision. Many failures which have occurred, especially where the structure is located in sea water, can be directly traced to ignorance or lack of supervision.

3. It is desirable that the concrete be deposited continuously from the time the work is started until it is brought above the water level, or to the finished surface, which can later be cleaned of laitance in the air after the concrete has hardened.

Of the methods used, the following give the best results:

1. The concrete is lowered in large buckets having a hinged bottom which sets sufficiently far above the lower edge of the bucket that it may open freely downward and outward when the bucket reaches the surface upon which the concrete is to be deposited. The top of the bucket is left open, and care is taken to see that the bucket is completely filled before lowering. Efforts made to use a closed top bucket have not been successful, due to the disturbance of the deposited concrete by inrush of water as the bucket is withdrawn.

2. The concrete may be passed through a vertical tube or tremie reaching down to the surface upon which the concrete is to be deposited. In this case the tremie should be kept filled with concrete at all times, and the flow should be as nearly continuous as practicable. When the operation starts, the tremie should be filled in such manner that the concrete is not permitted to drop through the water. This is accomplished in several ways: One is to place the bottom of the tremie in a box, partially filling it with concrete so as to seal the bottom, then lowering the tremie into the position in which it is to be used. Another method is to plug the tremie with cement sacks or other material, which will be forced down as the tube is filled with concrete. A third method is to plug the end of the tremie with a cloth sack filled with cement. In case the charge is lost, the tremie should again be filled as at first.

3. Jute or cloth bags, from two-thirds to three-fourths filled with concrete, have been used successfully. These are placed in a header and stretcher system so that the whole mass is interlocked.

4. Where it is difficult to construct a cofferdam or monolithic work is not required, premolded concrete blocks of large dimensions have been used successfully.

---

[11] Adopted, Vol. 21, 1920, pp. 114, 1361.

5. A concrete depositing bag made of canvas or other suitable material is a variation of the bucket system. This is filled with concrete and the mouth of the bag closed by one turn of a line so looped that a pull on the line will release it. The bag is lowered mouth down to the surface upon which the concrete is to be deposited, and a pull on the line opens the bag and permits the concrete to be deposited. This method does not have the disadvantage of the closed top bucket, since the bag will collapse as the concrete flows out.

Methods to be avoided:

1. There are a number of other methods that have been used, such as depositing directly through the water; depositing a portion of the concrete by one of the above methods in the corner of the form and the balance progressively from wheelbarrows or buckets on the sloping surface, thus gradually filling the form; allowing the concrete to partially set in air and then depositing it in a plastic condition; depositing the concrete dry without the use of water; attempting to grout a foundation composed of rip-rap or coarse gravel by means of pipes sunk at intervals into the foundation. Although occasionally fair results have been obtained, all of these methods are dangerous, as they almost uniformly result in segregation of the materials or the washing out of the cement.

Precautions.—Concrete to be deposited in water should be of a richer mixture than when deposited in air, and a leaner mixture than 1-2-4 should not be used.

The aggregate should be free from loam and other material, and it is preferable that washed aggregates be used where possible to obtain them. Washed gravel of somewhat smaller size than used in open air concrete will give the best results.

In depositing concrete under water it is imperative that the water be still and that the concrete shall not be exposed to current until it is fully set. This requires that a cofferdam be constructed in such manner as to insure quiet water within the cofferdam. One of the essentials of depositing concrete by any of the above methods is that the concrete be disturbed as little as practicable during the depositing, thus avoiding the formation of laitance. It is impracticable in depositing concrete in water by any method to entirely avoid laitance, and it is therefore necessary on completing a section of concrete to see that the laitance is entirely removed after the concrete has thoroughly set and before the work is resumed. For this reason when a job is started the concrete should be deposited continuously until the finished surface is reached or the concrete brought above the water level so that the laitance may be removed in the air, as it is difficult, if not impracticable, to entirely remove it under water. The formation of construction joints under water should be avoided.

The ordinary precautions used in depositing concrete in the air are not sufficient when depositing concrete in water, and additional care must be observed in the latter case to prevent segregation of the materials, the formation of laitance, and to insure proper setting of the mass. Because of the fact that cold retards setting, the concrete should not be deposited in water the temperature of which is low enough to cause serious retardation. Concrete should be thoroughly mixed before it is deposited in water and, therefore, hand mixing should never be permitted, but a batch mixer used.

[12]DESIGN OF RETAINING WALLS.

The following nomenclature is recommended:

$\varphi =$ the angle of repose of the filling.

$\theta =$ the angle between the back of the wall and a horizontal line passing through the heel of the wall and extending from the back into the fill.

$\delta =$ angle of surcharge, which is the angle between a horizontal line and the surface of the filling. (It is recommended that values of $\delta = 0$ or $\delta = \phi$ be used.)

$\lambda =$ the angle between the resultant thrust P and a horizontal line.

$h =$ vertical height of the wall in feet.

$h^1 =$ height of surcharge in feet.

$l =$ width of the base of the wall in feet.

$e =$ distance from the center of the base to the intersection of the resultant thrust E and the base.

$a = \quad e =$ distance from toe of wall to intersection of the resultant
2
thrust E and the base.

$P =$ the resultant earth pressure per foot of length of wall.

$E =$ the resultant of the earth pressure and the weight of the wall.

$F =$ vertical component of resultant E.

$w =$ the weight of the filling per cubic foot.

$w_1 =$ the weight of the masonry per cubic foot.

$W =$ total weight of the wall per foot of length.

p_1 and $p_2 =$ pressure per square foot on the foundation, due to F, at toe and heel, respectively.

FORMULAS.

The following formulas for vertical walls or for walls leaning away from the filling are based on Rankine's Theory, as given in Howe's "Retaining Walls," and in Ketchum's "Walls, Bins and Grain Elevators;" and the formulas for walls leaning toward the filling are based on a modification of Rankine's Theory, as given in Ketchum's "Walls, Bins and Grain Elevators."

---

[12] Adopted, Vol. 18, 1917, pp. 875, 1564.

For vertical walls with horizontal surcharge the pressure P is given by the formula

$$P = \frac{p_1}{2} wh^2 \frac{p^2 - \sin\phi}{1 + \sin\phi} = \frac{1}{2} wh^2 \tan^2 \left(45^\circ - \frac{\phi}{2}\right) \dots\dots\dots\dots (1)$$

where P is parallel to the top surface, is normal to the wall, and is applied at one-third the height of the wall above the base.

For the vertical walls with a positive surcharge ϕ the pressure P is given by the formula

$$P = \frac{1}{2} wh^2 \cos\delta \frac{\cos\delta - \sqrt{\cos^2\delta - \cos^2\phi}}{\cos\delta + \sqrt{\cos^2\delta - \cos^2\phi}} \dots\dots\dots\dots (2)$$

where P is parallel to the top surface of the filling, makes an angle δ with a normal to the back of the wall, and is applied at one-third the height of the wall above the base. Where the surcharge δ is equal to the angle of repose ϕ formula (2) becomes

$$P = \frac{1}{2} wh^2 \cos\Phi \dots\dots\dots\dots (3)$$

For a vertical wall with a loaded surcharge the resultant pressure on the back of the wall will be given by the formula

$$P = \frac{1}{2} wh \left(h + 2h^1\right) \frac{1 - \sin\phi}{1 + \sin\phi} \dots\dots\dots\dots (4)$$

where h is the height of the wall and h^1 is the equivalent height of surcharge, which is equal to the surcharge per square foot divided by w, the weight per cubic foot of the filling.

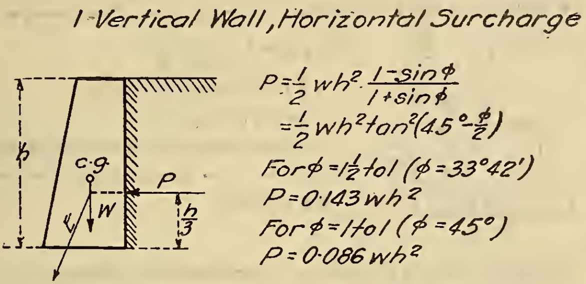
The resultant pressure is horizontal and is applied at a distance from the base of the wall equal to

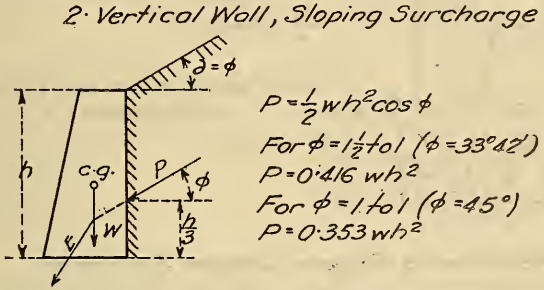
$$y = \frac{h^2 + 3hh^1}{3\left(h + 2h^1\right)} \dots\dots\dots\dots (5)$$

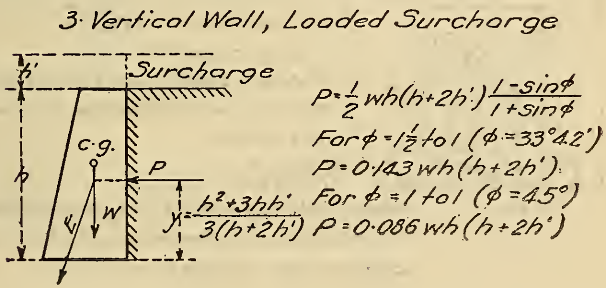
(a) In calculating the surcharge due to a track, the entire load shall be taken as distributed uniformly over a width of 14 feet for a single track or tracks spaced more than 14 feet centers, and the distance center to center of tracks where tracks are spaced less than 14 feet.

(b) In calculating the pressure on a retaining wall where the filling carries permanent tracks or structures, the full effect of the loaded surcharge shall be considered where the edge of the distributed load or the structure is vertically above the back edge of the heel of the wall. The effect of the loaded surcharge may be neglected where the edge of the distributed load or the structure is at a distance from the vertical line through the back edge of the heel of the wall equal to h, the height of the wall. For intermediate positions, the equivalent uniform surcharge load is to be taken as proportional. For example, for a track with the edge of the distributed load at a distance, $\frac{h}{2}$, from the vertical line through the back edge of the heel of the wall, the equivalent uniform surcharge load is one-half the normal distributed load distributed over the filling.

Figs. 15 to 18 explain the distribution. The height of surcharge loading will be equal to the load per linear foot divided by b ($b = 14$ feet for a single track railway). Where the edge of the distributed load cannot


1 Vertical Wall, Horizontal Surcharge
h
c.g.
W
P
h/3
P = ½ wh² (1 − sin φ)/(1 + sin φ)
= ½ wh² tan²(45° − φ/2)
For φ = 1½ to 1 (φ = 33°42′)
P = 0·143 wh²
For φ = 1 to 1 (φ = 45°)
P = 0·086 wh²



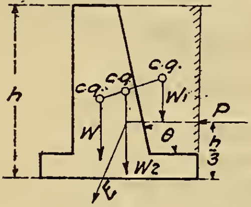

3· Vertical Wall, Loaded Surcharge
h′
Surcharge
h
c.g.
W
P
y = (h² + 3hh′)/(3(h + 2h′))
P = ½ wh(h + 2h′) (1 − sin φ)/(1 + sin φ)
For φ = 1½ to 1 (φ = 33°42′)
P = 0·143 wh(h + 2h′)
For φ = 1 to 1 (φ = 45°)
P = 0·086 wh(h + 2h′)

come nearer to the vertical line through the back of the heel of the wall than $h - x$, the equivalent uniformly distributed load in terms of height is

$$h'_x = h^1 \frac{x}{h}.$$

For walls leaning forward or walls with the base extending into the filling, the pressure of the filling on a vertical plane through back of the heel of the wall, as calculated above, is to be combined with the wedge of filling contained between this vertical plane and the back of the wall.

4. Wall Leaning Forward, Horizontal Surcharge



$P = \frac{1}{2} wh^2 \frac{1 - \sin\phi}{1 + \sin\phi}$

$= \frac{1}{2} wh^2 \tan^2 (45° - \frac{\phi}{2})$

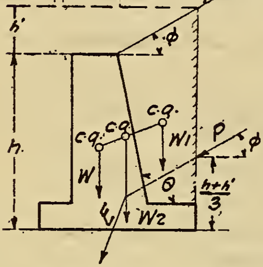
as in Case 1.

W = total weight of wall one ft. long.

W1 = " " earth wedge " " "

W2 = W + W1.

5. Wall Leaning Forward, Inclined Surcharge



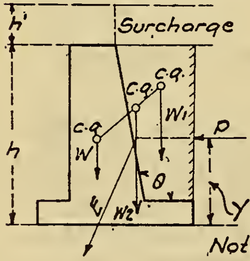
$P = \frac{1}{2} w (h + h')^2 \cos\phi$

W = total weight of wall one ft. long.

W1 = " " earth wedge " " "

W2 = W + W1

6. Wall Leaning Forward, Loaded Surcharge



h' = surcharge per sq. ft. ÷ w.

$P = \frac{1}{2} wh(h + 2h') \frac{1 - \sin\phi}{1 + \sin\phi}$

as in case 3

W = total weight of wall one ft. long.

W1 = " " earth wedge " " "

W2 = W + W1

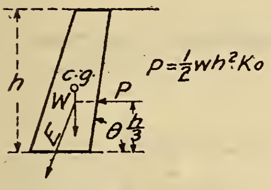
$Y = \frac{h^2 + 3h'h}{3(h + 2h')}$

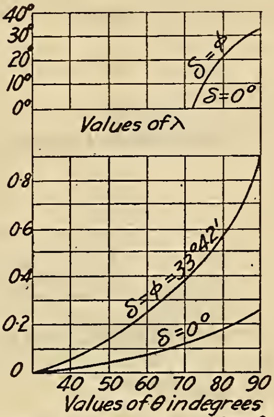
Note: Wall should be investigated when W1 includes surcharge, and when surcharge over wedge is omitted.

For walls leaning toward the filling the resultant pressure P will be horizontal for a wall without surcharge or with a horizontal loaded surcharge, and will make an angle λ with the horizontal for a wall with a sloping surcharge. The values of λ will vary from δ, where the wall is vertical, to zero, where Rankine's Theory shows that the resultant pressure is horizontal. Values of λ are given in Figs. 10 and 11. Values K, where $P = \frac{1}{2} wh^2 K$ are given in Figs. 10 and 11.

The formulas for the different cases above are given in Figs. 1 to 9.

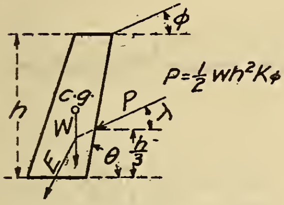
7·Wall Leaning Toward the Filling, Horizontal Surcharge



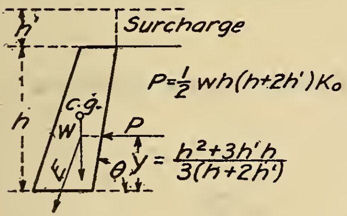


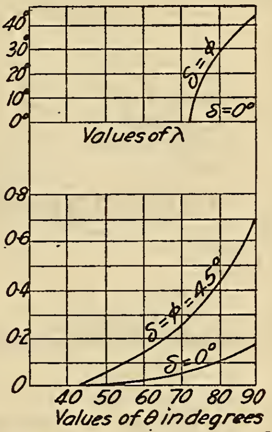
10·Values of Ko and Kφ for φ-33°42'

8·Wall Leaning Toward the Filling, Inclined Surcharge



9·Wall Leaning Toward the Filling·Loaded Surcharge





11·Values of Ko and Kφ for φ=45°

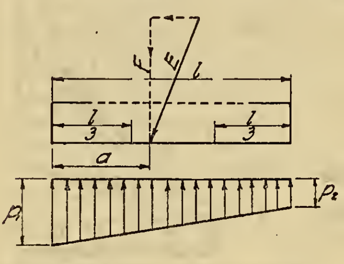
Discussion of Formulas.

Cases 1 to 3 are for vertical walls without heels. The pressure P is the same as the pressure on a vertical plane in the filling. Vertical walls with heels come under cases 4 to 6.

Cases 4 to 6 are for walls with heels. The wall may be vertical or may lean forward, or may lean backward as long as the upper edge of the back of the wall is in front of the vertical plane through the edge of the heel.

Cases 7 to 9 are for walls without heels. Walls with heels come under cases 4 to 6 as long as the upper edge of the back of the wall is in front of the vertical plane through the edge of the heel; if the upper edge of the

12 Pressures on Foundation. Resultant within Middle Third.

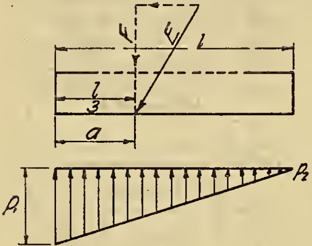


$$p_1 = (4l - 6a)\frac{F}{l^2}$$

$$p_2 = (6a - 2l)\frac{F}{l^2}$$

$$\text{when } a = \frac{l}{2},\ p_1 = p_2 = \frac{F}{l}$$

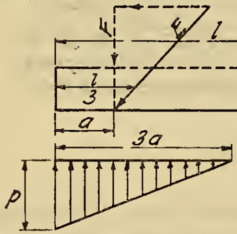
13-Pressures on Foundation, Resultant at edge of Middle Third.



$$p_1 = (4l - 6a)\frac{F}{l^2} = \frac{2F}{l}$$

$$p_2 = (6a - 2l)\frac{F}{l^2} = 0$$

14-Pressures on Foundation, Resultant outside Middle Third.



$$p = \frac{2F}{3a}$$

back of the wall extends back of the vertical plane through the edge of the heel, the problem can be solved by combining the solutions of cases 4 to 6 and 7 to 9.

Fig #15

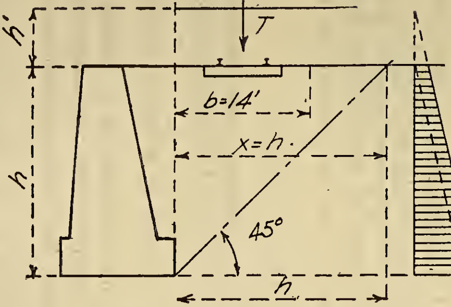


Fig #17

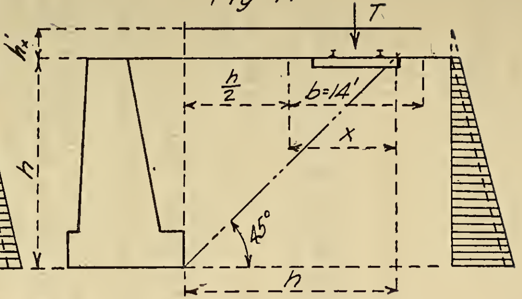


Fig #16

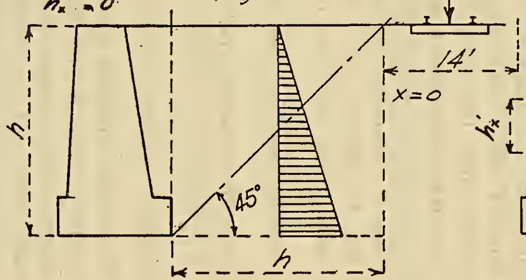
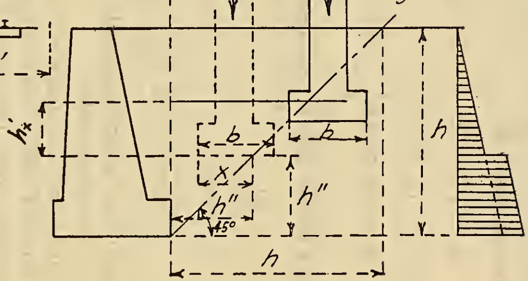


Fig #18



T = superimposed load per foot of wall b = width of distribution of T, in feet

$h' = T/iBW$ $h'_x = h'\frac{x}{h}$ w = weight of backfilling per cu. ft.

PRESSURE ON FOUNDATIONS.

The pressures on foundations will be calculated by the following formulas:

Where a is equal to or greater than $\frac{l}{3}$.

Pressure at the toe

$$p_1 = (4l - 6a)\frac{F}{l^2} \quad \text{(6)}$$

Pressure at the heel is

$$p_2 = (6a - 2l)\frac{F}{l^2} \quad \text{(7)}$$

Where a is less than $\frac{l}{3}$, the pressure at the toe is

$$p_1 = \frac{2F}{3a} \quad \text{(8)}$$

PRINCIPLES FOR DESIGN OF RETAINING WALLS.

The following principles should be observed in the design and construction of retaining walls:

(1) For usual conditions of the filling, use an angle of repose of 1½ to 1 ($\phi = 33° \ 42'$). For dry sand or similar material, a slope of 1 to 1 ($\phi = 45°$) may be used.

(2) The maximum pressure at the toe of the retaining wall should never exceed the safe bearing pressure on the material considered.

(3) When the retaining wall rests on a compressible material, where settlement may be expected, the resultant thrust E should strike at the middle or back of the middle of the base of the wall so that the wall will settle toward the filling ($a =$ or $> \frac{l}{2}$).

(4) When the retaining wall rests on a material where settlement may not be expected the resultant thrust E should not strike outside the middle third of the base ($a =$ or $> \frac{l}{3}$), except as noted in (5) below.

(5) Where the retaining wall rests on solid rock or is carried on piles the resultant thrust E may strike slightly outside the middle third, provided the wall is safe against overturning, and also provided the maximum allowable pressure is not exceeded.

(6) In order that the retaining wall may be safe against sliding, the frictional resistance of the base, combined with the abutting resistance of the earth in front of the wall, must be greater than the horizontal thrust on the back of the wall.

(7) The filling back of the wall should be carefully drained so that the wall may not be subjected to hydrostatic pressure.

(8) The foundation for a retaining wall should always be placed below frost line.

(9) A careful study should be made of the conditions in the design of each wall, and it should be remembered that no theoretical formulas can be more than an aid to the judgment of the experienced designer. The main value of theoretical formulas is in obtaining economical proportions, in obtaining a proper distribution of the stresses, and in making experience already gained more valuable.

[13]MONOLITHIC CONSTRUCTION.

These conclusions are based upon the supposition that the structure is well designed and that the foundation is good:

(1) Monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

(2) Where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

(3) Reinforced concrete abutments may be built in units of any length that economic conditions will permit.

(4) Monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints.

[14]WATERPROOFING OF MASONRY.

(1) Watertight concrete may be obtained by proper design. Reinforcing the concrete against cracks due to expansion and contraction, using the proper proportion of cement and graded aggregates to secure the filling of voids and employing proper workmanship and close supervision.

(2) Membrane waterproofing, of either asphalt or pure coal-tar pitch in connection with felts and burlaps, with proper number of layers, good materials and workmanship and good working conditions, is recommended as good practice for waterproofing masonry, concrete and bridge floors.

---

[13] Adopted, Vol. 12, Part 1, 1911, pp. 516, 580.
[14] Adopted, Vol. 15, 1914, pp. 536, 1061.

(3) Permanent and direct drainage of bridge floors is essential to secure good results in waterproofing.

(4) Integral methods of waterproofing concrete have given some good results. Special care is required to properly proportion the concrete, mix thoroughly and deposit properly so as to have the void-filling compounds do the required duty; if this is neglected, the value of the compounds is lost and their waterproofing effect destroyed. Careful tests should be made to ascertain the proper proportions and effectiveness of such compounds.

Integral compounds should be used with caution, ascertaining their chemical action on the concrete as well as their effect on its strength. As a general rule, integral compounds are not recommended, since the same results as to watertightness can be obtained by adding a small percentage of cement and properly grading the aggregate.

(5) Surface coating, such as cement mortar, asphalt or bituminous mastic, if properly applied to masonry reinforced against cracks produced by settlement, expansion and contraction, may be successfully used for waterproofing arches, abutments, retaining walls, reservoirs, and similar structures; for important work under high pressure of water these cannot be recommended for all conditions.

(6) Surface brush coatings, such as oil paints and varnishes, are not considered reliable or lasting for waterproofing of masonry.

[15]DISINTEGRATION OF CONCRETE AND CORROSION OF REINFORCING METAL.

(1) Concrete for sea water work should be mixed in the proportions of one part Portland Cement to not more than six parts of fine and coarse aggregates, measured separately and combined in such proportions as will produce a concrete of maximum density and impermeability. Only enough water should be added to secure plastic workability. The concrete should be mixed in a batch mixer for not less than two minutes after all the materials are in the drum. Where concrete is deposited into sea water, the above proportions should be reduced to one part of cement to not more than five parts of separately measured aggregates. Tests should be made from time to time during the progress of the work to maintain the proper proportions of the aggregates throughout construction.

---

[15] Adopted, Vol. 15, 1914, pp. 568, 1062.

(2) Concrete should be deposited in the air wherever practicable. When necessary to deposit concrete in water, it should be protected from currents by cofferdams or similar means.

(3) The concrete, where practicable, should be deposited in a continuous operation to a point 5 ft. above high water. In case of unavoidable stoppage of the work, the previously cast concrete should be thoroughly cleaned of all laitance.

(4) From 2 ft. below low water to 2 ft. above high water, or from a plane below to a plane above wave action, the face of the concrete should be adequately protected against mechanical abrasion and frost action. Construction or other joints should in every case be avoided within this zone. Sharp corners and projections should also be avoided, but where necessary they should be rounded to reduce abrasion to a minimum.

(5) If reinforcement is used in concrete in sea water, special attention should be given in the design to the position of the reinforcement. In no case should the steel be nearer than 3 in. to any plane or curved surface, and not less than 4 in. from any two adjacent surfaces.

(6) The most rigid rules in regard to workmanship and inspection should be established and constantly enforced on all sea water work.

[16]METHOD OF REPAIRING DEFECTIVE OR WORN SURFACES OF CONCRETE.

(1) In all cases the surface to be repaired must first be thoroughly cleaned of all loose material, laitance and dust and the clean, rough, sound concrete exposed to receive the patch. Probably the best method of cleaning is by means of a steam jet.

(2) After cleaning, the surface to be repaired must be thoroughly saturated with water, not simply moistened, but so thoroughly drenched that the old concrete will not absorb water from the new mortar or concrete used in patching. If possible, the surface should be kept covered with water for several hours.

(3) If the repair or patch is to be made on a vertical or sloping surface and is not to be more than 1½ in. thick, the surface of the old concrete, while it is still wet, should be spattered or splashed with a cement grout, following this immediately with a fairly stiff plaster coat of mortar made of the same proportions of cement and sand as was used in the original concrete, but never richer than 1 cement to 2½ sand.

---

[16] Adopted, Vol. 13, 1912, pp. 476, 991-992.

This plaster coat should not be thicker than ½-in. and each coat should be forced into the surface, but not dragged with a trowel. The surface of each coat, except the final coat, should be "scratched" to give a bond for the next coat. This plastering should preferably begin at the top and progress downward, and only enough time be allowed to permit each coat to receive its initial set before the next coat is applied. The final coat should be finished with a wooden float and only enough water used to properly finish the surface. This patch should be kept damp and protected from sun or frost till fully set up.

(4) If the repair or patch or "finish coat" is to be made on a horizontal or nearly horizontal surface, the surface of the old concrete should be slushed and broomed with a thin cement grout, following this immediately with a *wet* mortar made of 1 part cement and 2½ parts sand or granite screenings and of the full thickness required (not less than ½-in. thick, however). When this mortar begins to take its initial set, it should be floated or troweled to such a finish as may be desired.

(5) If the repair or patch is to be made on a vertical or sloping face and is to be more than 1½ in. thick, it will be advisable to embed dowels into the old concrete, as deeply as the thickness of the proposed patch, and spaced sufficiently close together to firmly anchor the patch to the old concrete. The dowels must be wedged into the old concrete and it will be advisable to fasten wires, metal fabrics or bars to the dowels in the case of extensive patching, as an additional safeguard. The patching may then be done with mortar without forms, or with wet concrete supported by forms, depending upon the thickness and the extent of the patch.

(6) If the repair or patch is to be made on a horizontal or nearly horizontal face and of considerable thickness, dowels may be used, or the concrete may simply be reinforced by fabric or bars without using dowels—treating the patch as a block of masonry.

(7) Care must be taken not to have thin edges on patches. To avoid this, it may be necessary to cut out sound concrete around a place to be patched, so as to give deep edges to the patch. If possible, the edges should be undercut.

COMMITTEE IX.

SIGNS, FENCES AND CROSSINGS.

[1] DEFINITIONS.

FENCES.

FENCE.—A barrier that serves to guard against unrestricted ingress or egress, generally a line of posts with rails or wire, or rails and vertical boards or pickets.

POST.—A piece of wood, metal or other material, set upright and used to support the longitudinal members of a fence.

END POST.—A post at the end of a line or section of fence.

CORNER POST.—A post located at the intersection of two lines or sections of fence.

ANCHOR POST.—A post located between end or corner posts and used as an anchor for stretching wire.

INTERMEDIATE OR LINE POST.—A post placed between end or corner posts.

RAIL.—Any longitudinal member of a fence other than wire.

CLEAT.—A piece of wood, metal or other material, fastened transversely to the side of a post below the ground to give it greater stability.

BRACE.—A piece of wood, metal or other material, in compression, placed diagonally between adjacent posts.

TIE.—A piece of wood, metal or other material, in tension, between adjacent posts.

PANEL.—A section of fence between two adjacent posts.

BRACE PANEL.—A panel in which a brace or tie, or both, are introduced.

STAY.—A piece of wood, metal or other material, used to stiffen the fence and to maintain the spacing of the longitudinal wires.

STAPLE.—A metal device in the shape of a letter "U" with sharpened ends for fastening the longitudinal wires of the fence to the posts.

GATE.—A movable barrier consisting of a structure of wood, metal or other material, for closing a passageway or an opening in a fence.

GATE FRAME.—The sustaining part of a gate, fitted and framed together, to which the other members are attached.

---

[1] Adopted, Vol. 5, 1904, pp. 381, 382, 386, 390, 446-451, 458, 459; Vol. 16, 1905, pp. 781, 782; Vol. 7, 1906, pp. 458, 479; Vol. 10, Part 1, 1909, pp. 885, 915-917; Vol. 11, Part 2, 1910, pp. 1230, 1231, 1246; Vol. 16, 1915, pp. 435, 486, 1039-1041.

GATE BRACE.—A piece of wood, metal or other material, in compression, placed diagonally and used to stiffen the frame of a gate.

GATE TIE.—A piece of wood, metal or other material, in tension, placed diagonally and used to stiffen the frame of a gate.

GATE POST.—A post on which a gate is carried or to which it is latched.

SNOW FENCE.—A structure erected for the purpose of forming artificial eddies on the windward side of a cut at sufficient distance away to cause snow to deposit between the snow fence and the cut.

SURFACE STOCK-GUARDS.

STOCK-GUARD.—A barrier of wood, metal or other material placed between and alongside of track rails to prevent the passage of live stock on or along the railroad track or tracks.

SLAT.—A strip of wood, metal or other material used in making up a surface stock-guard.

FILLER.—A piece of wood, metal or other material placed between the slats to space and stiffen them.

APRON.—A flared panel of fence set parallel with the track and along outside edge of a stock-guard.

WING FENCE.—A fence connecting the apron of the stock-guard with the right-of-way or line fence.

[2] SPECIFICATIONS FOR STANDARD RIGHT-OF-WAY FENCES.

Classes.

1. Standard right-of-way fences shall be divided into four classes, the height to conform to statutory requirements, generally about 4 feet 6 inches above the ground.

Class A Fence.

2. Class A fence shall consist of nine longitudinal smooth galvanized steel wires; the top and bottom wires shall be No. 7 gage; the intermediate and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires (commencing at the bottom) shall be 4, 4½, 5, 5½, 6, 7, 8 and 9 inches. The bottom wires shall be five inches above the ground and the stay wires shall be spaced twelve inches apart.

---

[2] Adopted, Vol. 5, 1904, pp. 386-390, 458, 459; Vol. 7, 1906, pp. 451-456, 478; Vol. 11, Part 2, 1910, pp. 1231-1234, 1246; Vol. 16, 1915, pp. 436-443, 1040; Vol. 22, 1921, pp. 269, 997.

When used as a hog-tight fence, a strand of barbed wire shall be added 2½ inches below the woven wire.

Class B Fence.

3. Class B fence shall consist of seven longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires, commencing at the bottom, shall be 6½, 7, 7½, 8, 8½ and 9 inches. The bottom wire shall be seven inches above the ground and stay wires shall be spaced twelve inches apart.

Class C Fence.

4. Class C fence shall consist of woven wire fencing 25½ inches high with three strands of barbed wire above. The woven wire fencing shall consist of seven longitudinal, smooth, galvanized steel wires. The longitudinal and stay wires shall be No. 9 gage and the stay wires shall be 12 inches apart. The spacing of the longitudinal wires, commencing at the bottom, shall be 3, 3½, 4, 4½, 5 and 5½ inches, and the bottom wire shall be 2 inches above the ground. The spacing of the barbed wires above the woven wire shall be 4½, 10 and 12 inches.

Class D Fence.

5. Class D fence shall consist of five strands of galvanized steel ribbon, smooth, round or barbed wire fencing.

The spacing of the wires, commencing at the bottom, shall be 10, 10, 12 and 12 inches. The bottom wire shall be ten inches above the ground.

The longitudinal wires of all woven wire fencing under Classes A, B and C shall be provided with tension curves to take up expansion and contraction.

MATERIAL.

Wood Posts.

6. Posts shall be made of cedar, locust, chestnut, Bois d'Arc, white oak, mulberry, catalpa or other durable wood native to the locality or of treated timber. They shall be straight and free from splits, rot or other defects.

If sawed or split posts are used, their dimensions shall be at least equal to those hereinafter specified for round posts.

End Posts, Etc.

7. End, corner, anchor and gate posts shall be at least 8 feet long and 8 inches in diameter at the small end, set 3 feet 4 inches in the ground.

Intermediate Posts.

8. Intermediate or line posts shall be at least 7 feet long and 4 inches in diameter at the small end, set 2 feet 4 inches in the ground.

Braces.

9. Braces for end, corner, anchor and gate posts shall be made of intermediate or line posts or 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, and free from large knots, splits, rot and other defects.

Wire.

10. Woven wire fences shall be constructed of basic open-hearth galvanized steel wire. It must stand, without sign of fracture, winding tight around wire of the same size.

Locks.

11. The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

Staples.

12. The staples used for fastening the longitudinal wires to the posts shall be made of No. 9 galvanized steel wire. They shall be 1 inch long for hardwood and 1½ inches long for softwood.

Galvanizing.

13. The galvanizing shall consist of an even coating of zinc, which shall withstand four one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, the specific gravity of which shall be 1.185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. Immediately after each immersion the sample shall be washed in water and wiped dry. If the zinc is removed, or a copper-colored deposit formed at the end of the fourth immersion, the lot of material from which the sample is taken shall be rejected.

Manufacture.

14. The fence shall be so fabricated as not to remove the galvanizing or impair the tensile strength of the wire.

Erection.

End, Corner, Anchor and Gate Posts.

15. End, corner, anchor and gate posts shall be set vertical, at least 3 feet 4 inches in the ground, thoroughly tamped, braced and anchored.

Intermediate or Line Posts.

16. Intermediate or line posts shall be set at least 2 ft. 4 in. in the ground and not more than 20 ft. apart, center to center. The first line post from any corner, anchor or gate post shall be set 10 ft., center to center, from the same.

Post Holes.

17. Holes of full depth shall be provided for all end, corner, anchor and gate posts, even if blasting must be resorted to. For intermediate or line posts, where rock is encountered, not more than two adjacent wood posts shall be set on sills 6 inches by 6 inches by 4 feet long, braced on both sides by 2-inch by 6-inch braces, 3 feet long. Holes shall be provided for all other posts. Posts shall be set with large end down and in perfect line on the side on which the wire is to be strung. After the fence is erected, the tops of the wood posts shall be sawed off with a one-fourth pitch, the high side being next the wire and 2 inches above it.

Anchoring.

18. Wood end, corner, anchor and gate posts shall be anchored by gaining and spiking two cleats to the side of the posts, at right angles to the line of the fence, one at the bottom, the other just below the surface of the ground. The cleat near the ground surface shall be put on the side next the fence and the bottom cleat shall be put on the opposite side. Intermediate wood posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

Cleats, Sills, Etc.

19. All cleats shall be 2 inches by 6 inches by 2 feet long. All sills, braces and cleats shall be made of sawed lumber of a quality equal in durability to that of the posts.

Bracing.

20. Wood end, corner, anchor and gate posts shall be braced by using an intermediate or line post or a piece of 4-inch by 4-inch sawed lumber of a quality equal in durability to that of the posts, gained into the end, corner, anchor or gate post, about 12 inches from the top and into the next intermediate or line post about 12 inches from the ground and be securely spiked. A cable made of a double strand of No. 9 galvanized soft wire looped around the end, corner, anchor or gate post near the ground line, and around the next intermediate

or line post about 12 inches from the top, shall be put on and twisted until the top of the next intermediate or line post is drawn back about 2 inches.

Stretching.

21. Longitudinal wires shall be stretched uniformly tight and parallel; stays shall be straight, vertical and uniformly spaced. Wires shall be placed on the side of the post away from the track.

Stapling.

22. Staples shall be set diagonally with the grain of the wood and driven home tight. The top wires shall be double stapled.

Splicing.

23. Approved bolt clamp splice or a wire splice made as follows may be used: The ends of the wires shall be carried 3 inches past the splicing tools and wrapped around both wires backward from the tool for at least five turns, and after the tool is removed, the space occupied by it shall be closed by pulling the ends together.

TABLE SHOWING QUANTITY OF MATERIAL NEEDED FOR BARBED WIRE AND BOARD FENCES.

Spacing of Posts.	Posts.			Staples.								
	Posts—No. Required.			Staples Required in Pounds—1 Strand of Wire.								
	Per Rod	Per 100	Per Mile	Per Rod.			Per 100 feet.			Per Mile.		
				1 in.	1¼ in.	1½ in.	1 in.	1¼ in.	1½ in.	1 in.	1¼ in.	1½ in.
8	2.06	12.50	660.0	0.02	0.03	0.03	0.12	0.15	0.18	6.41	7.96	9.57
10	1.65	10.00	528.0	0.02	0.02	0.03	0.10	0.12	0.15	5.13	6.36	7.66
12	1.38	8.33	440.0	0.02	0.02	0.02	0.08	0.10	0.13	4.28	5.30	6.38
14	1.18	7.16	378.0	0.02	0.02	0.02	0.07	0.09	0.11	3.68	4.56	5.48
16	1.03	6.25	330.0	0.01	0.02	0.02	0.06	0.08	0.10	3.20	4.00	4.78
16½	1.00	6.06	320.0	0.01	0.02	0.02	0.06	0.08	0.09	3.11	3.86	4.64
18	0.92	5.57	294.0	0.01	0.02	0.02	0.06	0.07	0.08	2.86	3.54	4.26
20	0.83	5.00	264.0	0.01	0.01	0.02	0.05	0.06	0.07	2.56	3.18	3.83
22	0.75	4.54	240.0	0.01	0.01	0.02	0.05	0.06	0.07	2.34	2.89	3.48
24	0.69	4.17	220.0	0.01	0.01	0.01	0.04	0.05	0.06	2.14	2.66	3.19
26	0.64	3.86	204.0	0.01	0.01	0.01	0.04	0.05	0.06	2.00	2.46	2.96
28	0.59	3.58	189.0	0.01	0.01	0.01	0.04	0.04	0.06	1.84	2.28	2.74
30	0.55	3.34	176.0	0.01	0.01	0.01	0.03	0.04	0.05	1.71	2.12	2.55

Nails.					
Nails Required in Pounds—1 Board.					
Per Rod.		Per 100 feet.		Per Mile.	
8d Com.	10d Com.	8d Com.	10d Com.	8d Com.	10d Com.
0.07	0.10	0.39	0.60	20.7	31.5
0.07	0.11	0.41	0.64	22.0	33.5
0.06	0.09	0.35	0.53	18.3	28.0
0.05	0.08	0.30	0.46	15.7	24.0
0.05	0.07	0.26	0.40	13.7	21.0

NOTE—The quantity of nails required is figured on a basis of two nails to a board to each post.

Where posts are 8 feet apart it is figured to use a board 16 feet long.

BARBED WIRE FENCE.

Style of Wire.	Gage of Strand.	Spacing of Barbs.	Weight in Pounds.		
			Per Rod	Per 100 ft.	Per Mile
Baker's Perfect Regular or Cattle, 2 pt	12½	5 in.	0.88	5.31	280.0
" " Thickset or Hog, 2 pt	12½	3 "	0.97	5.87	310.0
Ellwood, Regular or Cattle, 4 pt	12½	5 "	0.94	5.68	300.0
" Thickset or Hog, 2 pt	12½	3 "	1.00	6.06	320.0
" Glidden, Regular or Cattle, 2 pt	12½	5 "	0.92	5.60	295.0
" " Thickset or Hog, 2 pt	12½	3 "	0.99	5.97	315.0
" Junior, Regular or Cattle, 2 pt	12½	5 "	0.88	5.31	280.0
" " Thickset or Hog, 2 pt	12½	3 "	0.94	5.68	300.0
American Glidden, Regular or Cattle, 2 pt	12	5 "	1.00	6.06	320.0
" " Thickset or Hog, 2 pt	12	3 "	1.08	6.54	345.0
Lyman, Regular or Cattle, 4 pt	12	5 "	1.14	6.92	365.0
" Thickset or Hog, 4 pt	12	3 "	1.25	7.58	400.0
Waukegan, Regular or Cattle, 2 pt	12½	5 "	0.87	5.26	277.5
" Thickset or Hog, 2 pt	12½	3 "	0 94	5.68	300.0

BOARD FENCE.

Size of Board.	Ft. B. M.		
	Per Rod	Per 100 ft.	Per Mile.
1 in. x 4 in.	5.50	33.33	1760.0
1 x 6	8.25	50.00	2640.0
1 x 8	11.00	66.67	3520.0
1 x 10	13.75	83.34	4400.0
1 x 12	16.50	100.00	5280.0

NOTE—The material given on the above tables is for one wire or one board high, in order that the material for fences of any number of wires or boards may be figured for different styles of wire and different sizes of boards.

Number of pounds of nails and staples is figured on an allowance of 5 per cent. to 100 per cent. for loss.

Smooth Steel Wires.

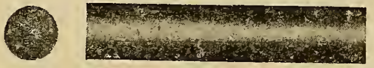
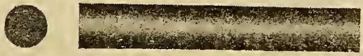
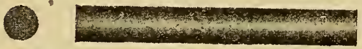
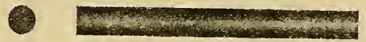
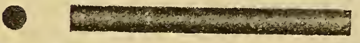
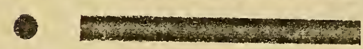
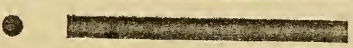
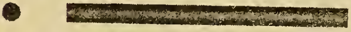
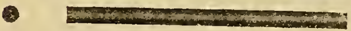
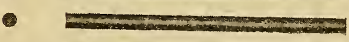
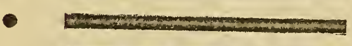
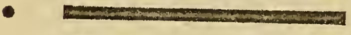
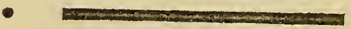
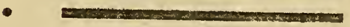
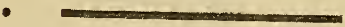
Cuts showing exact sizes of No. 1 to No. 20 gage steel wire by American Steel & Wire Company gage.	Gage.	Lb. to Mile	Feet to 1 lb.
	1	1121	4.71
	2	968	5.45
	3	833	6.34
	4	707	7.47
	5	599	8.81
	6	514	10.28
	7	439	12.05
	8	367	14.37
	9	306	17.24
	10	255	20.70
	11	202	26.18
	12	154	34.25
	13	118	44.64
	14	89	59.17
	15	72	73.00
	16	55	95.24
	17	41	129.87
	18	31	172.11
	19	24	222.22
	20	17	312.50

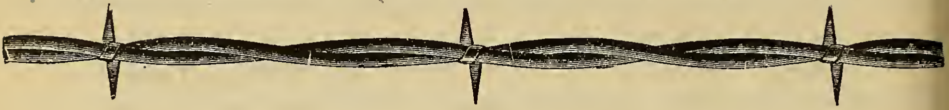
TABLE OF COMPARATIVE SIZES OF WIRE GAGE—IN DECIMALS OF AN INCH.

No. of Wire Gauge.	A. S. & W. Co., or Washburn & Moen.	Birmingham, or Stubb's.	Brown & Sharpe.	English Legal Standard.	Old English, or London.
000000	.460	....	......	.464	.....
00000	.430	....	......	.432	.....
0000	.393	.454	.46000	.400	.4540
000	.362	.425	40964	.372	.4250
00	.331	.380	.36480	.348	.3800
0	.307	.340	.32495	.324	.3400
1	.283	.300	.28930	.300	.3000
2	.263	.284	.25763	.276	.2840
3	.244	.259	.22942	.252	.2590
4	.225	.238	.20431	.232	.2380
5	.207	.220	.18194	.212	.2200
6	.192	.203	.16202	.192	.2030
7	.177	.180	.14428	.176	.1800
8	.162	.165	.12849	.160	.1650
9	.148	.148	.11443	.144	.1580
10	.135	.134	.10189	.128	.1340
11	.120	.120	.09074	.116	.1200
12	.105	.109	.08081	.104	.1090
13	.092	.095	.07196	092	.0950
14	.080	.083	.06408	.080	.0830
15	.072	.072	.05707	.072	.0720
16	.063	.065	.05082	.064	.0650
17	.054	.058	.04526	.056	0580
18	.047	.049	.04030	.048	.0490
19	.041	.042	.03589	.040	.0400
20	.035	.035	.03196	.036	.0350
21	.032	.032	.02846	.032	.0315
22	.028	.028	.02535	.028	.0295
23	.025	.025	.02257	.024	.0270
24	.023	.022	.02010	.022	.0250
25	.020	.020	.01790	.020	.0230
26	.018	.018	.01594	.018	.0205
27	.017	.016	.01419	.0164	.01875
28	.016	.014	.01264	.0148	.01650
29	.015	.013	.01126	.0136	.01550
30	.014	.012	.01002	.0124	.01375
31	.0135	.010	.00893	.0116	.01225
32	.0130	.009	.00795	.0108	.01125
33	.0110	.008	.00708	.0100	.01025
34	.0100	.007	.00630	.0092	.00950
35	.0095	.005	.00561	.0084	.00900
36	.0090	.004	.00500	.0076	.00750
37	.0085	....	.00445	.0068	.00650
38	.0080	....	.00396	.0060	.00575
39	.0075	....	.00353	.0052	.00500
40	.0070	....	.00314	.0048	.00450

BAKER PERFECT. TWO POINT.

Flat barbs, short and sharp.

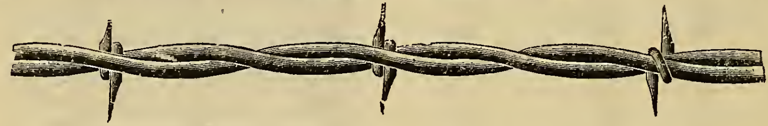
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



ELLWOOD JUNIOR, TWO POINT.

Half-round Barbs, short and sharp.

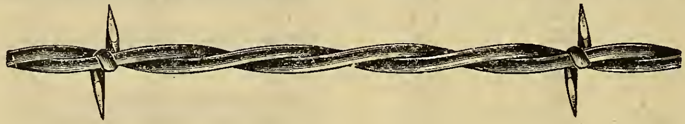
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



WAUKEGAN. TWO POINT.

Half-round Barbs, short and sharp.

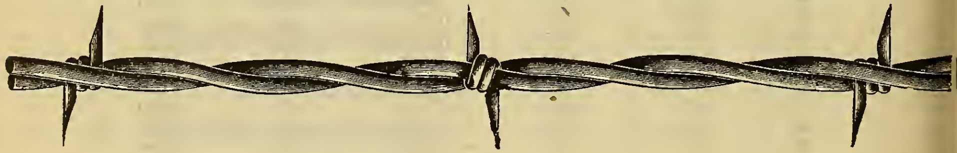
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



AMERICAN GLIDDEN. TWO POINT.

Round Barbs.

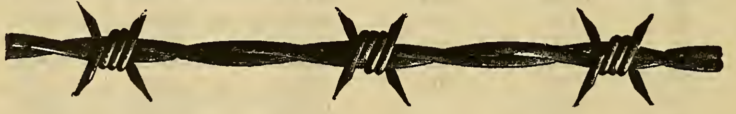
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



LYMAN, FOUR POINT.

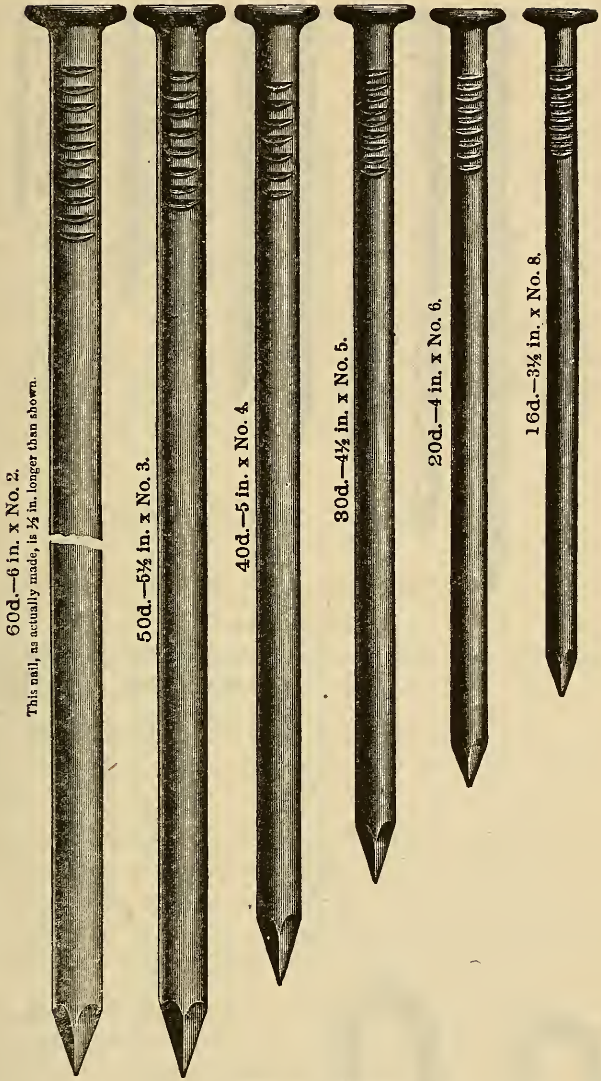
Round Barbs.

Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



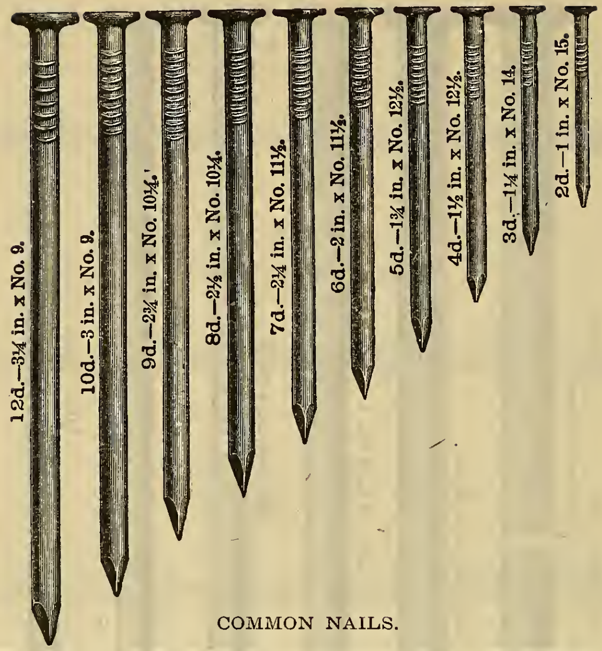
BARBLESS FENCING.

Two-Ply Twisted Galvanized Barbless Fencing. Sizes 11 to 14 inclusive.
3-Ply, 4-Ply, 5-Ply and 6-Ply Twisted Barbless Fencing. Sizes 7 to 14 inclusive.



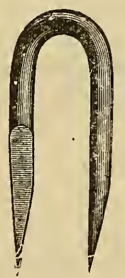
COMMON NAILS.

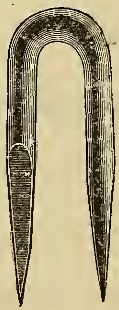
Size.	Length and Gage.		Approximate No. to lb.
16d.............................	3½ inch	No. 8	49
20d.............................	4 "	" 6	31
30d.............................	4½ "	" 5	24
40d.............................	5 "	" 4	18
50d.............................	5½ "	" 3	14
60d.............................	6 "	" 2	11



COMMON NAILS.

Size.	Length and Gage.		Approximate No. to lb.
2d..........................	1 inch	No. 15	876
3d..........................	1¼ "	" 14	568
4d..........................	1½ "	" 12½	316
5d..........................	1¾ "	" 12½	271
6d..........................	2 "	" 11½	181
7d..........................	2¼ "	" 11½	161
8d..........................	2½ "	" 10¼	106
9d..........................	2¾ "	" 10¼	96
10d..........................	3 "	" 9	69
12d..........................	3¼ "	" 9	63


1¼ in.


1½ in.

FENCE STAPLES.

Length.	No. to lb.
⅞	120
1	108
1⅛	96
1¼	87
1½	72
1¼	65
2	58

[3] GATES FOR RIGHT-OF-WAY FENCES.

(1) A hinged metal gate is recommended.

(2) The width of farm gates should be not less than 12 feet, depending upon the size of agricultural machinery in use in the vicinity, or as required by the laws of the States through which the railway operates. The minimum height of farm gates should be 4 feet 6 inches from the surface of the roadway.

(3) Farm gates should be hinged so as to open away from the track, and, if hinged, swing shut by gravity, and the end of the gate opposite the hinged end should lap by the post a sufficient distance to prevent it from being opened by side pressure.

[4] CONCRETE FENCE POSTS.

(1) Concrete fence posts are practical, economical and a suitable substitute for wood.

(2) Reinforcement should be placed as near to the surface of the post as practicable, say ½ inch from surface.

(3) Posts should taper from base to top.

(4) Square corner posts should be rounded off to radius of not less than 1 inch.

(5) Concrete should be made from clean, hard aggregates, the percentage of the various sized grains being such as to produce a dense concrete, using screen analysis as a guide. The minimum size of the particles of gravel or crushed stone should not be less than ¼ inch nor more than ½ inch. Concrete should be mixed in the proportion of one part cement to not more than four parts of mixed aggregate. Concrete should be of such a consistency that water can be brought to the surface by tamping; the use of an excess of water is detrimental. Concrete should be very thoroughly mixed in a batch, not a continuous mixer.

(6) Reinforcing should be in the form of stiff round or square rods, preferably deformed, made from steel with a high elastic limit. Crimped or stranded reinforcing that would be straightened out when brought

---

[3] Adopted, Vol. 8, 1907, pp. 528, 533; Vol. 10, 1909, Part 2, pp. 876, 910; Vol. 11, 1910, Part 2, pp. 1234, 1246; Vol. 16, 1915, pp. 440, 1140.

[4] Adopted, Vol. 10, Part 2, 1909, pp. 898, 916, 917; Vol. 11, Part 2, 1910, pp. 1243, 1244, 1246; Vol. 16, 1915, pp. 440, 1040; Vol. 19, 1918, pp. 671, 1238.

into tension should not be used. Some method of positively holding the reinforcing in its proper place in the post throughout its entire length should be used.

(7) Jogging or vibrating molds to compact the concrete in the post, or some other method that will accomplish the same purpose, should be employed.

(8) Posts should be carefully made so as to secure a uniform strength in substantially all posts, and this strength should usually be such that the post will withstand a force of not less than 180 lb. at right angles to the axis of the post, the post acting as a cantilever beam supported at the ground line and the force being applied 60 in. above the ground line. It is not economical to make posts that will have the strength to resist a force of over 200 lb. when the post is tested in the manner above described.

(9) Square, or nearly square, posts are more efficient than round posts in resisting the forces that ordinarily cause failure, but the difference is not very great and may in some cases be offset by an increased resistance to deterioration and better methods of manufacture.

(10) Posts should not be made out of doors in freezing weather. They should not be exposed to the sun, and should be sprinkled with water the first eight or ten days after being made to aid curing.

(11) Molds should be carefully oiled or soaked to prevent concrete sticking to them.

(12) Posts should be cured for not less than 90 days, when cured naturally, before being set or shipped.

(13) Posts should be carefully handled and packed in straw, sawdust or other suitable material for shipment.

(14) The study of the results obtained from concrete line posts should be continued from year to year and the results tabulated for the information of the Association.

[5] SURFACE STOCK-GUARDS.

General Requirements.

(1) A stock-guard should be so constructed as to avoid projecting surfaces liable to be caught by loose or dragging portions of equipment.

---

[5] Adopted, Vol. 5, 1904, pp. 387, 390, 459, 461, 462; Vol. 11, Part 2, 1910, 1231, 1246; Vol. 16, 1915, pp. 443, 1041.

(2) It should be effective against all live-stock, have no parts which would catch or hold animals or unnecessarily endanger employés who pass over it in the discharge of their duties.

(3) It should be reasonable in first cost, durable and easily applied and removed, so as to permit repairs to track at minimum expense.

(4) It should not rattle during passage of trains.

[6]SNOW FENCES, SNOW SHEDS AND RECOMMENDED METHODS OF SNOW REMOVAL.

Snow is carried by the wind close to the surface of the ground and is deposited in railway cuts on account of the eddies which they cause in the wind. The function of the snow fence is to form artificial eddies on the windward side of the cut at sufficient distance to cause the snow to deposit between the snow fence and the cut.

The location of the drift or eddy depends upon the form of the fence. A tight fence of sufficient height causes the snow to accumulate on the windward side of the fence; an open fence causes the snow to accumulate principally on the leeward side. The distance between the drift and the fence depends upon the height of the fence, the width of the openings between the boards, the velocity of the wind and the character of the snow.

The character of a snow fence and its location for the protection of a given point depends largely upon local conditions, some of which can only be determined by experiment, and for this purpose portable snow fences are recommended.

Where local conditions permit, a permanent snow fence located on the right-of-way is most economical.

Where permanent wood fences are used, the boards should be laid close, where the right-of-way is 50 feet or less from the center of the track; for greater distances, space should be provided between the boards and at a distance of 100 feet, 50 per cent. of the fence should be open space.

The height of permanent board fences depends upon the probable amount of snow. The maximum height, however, should not exceed ten feet.

In most cases local conditions require the use of a portable snow fence. These fences are usually erected in the fields adjoining the right-of-way. They should be set on the windward side of the track at right angles to the prevailing winds; to provide for variations in the direction of the wind, it is sometimes necessary to set the panels in crescent form. For ordinary conditions one line of fence is sufficient. The quantity of snow sometimes, however, requires the use of three or four lines of portable snow fences set parallel and spaced about 100 feet apart. These fences should be removed in the spring so as not to interfere with farming operations.

---

[6] Adopted, Vol. 10, Part 2, 1909, pp. 877, 881-887, 915-917; Vol. 11, Part 2, 1910, 1239-1241, 1246; Vol. 16, 1915, pp. 441, 1040.

Hedge fences may be used where the quantity of snow is not too great, and where local conditions, including the economic feature, permit. Properly maintained hedge fences are effective in beautifying the right-of-way.

Stone walls may be used for snow fences where suitable stones for dry masonry walls are available.

Temporary snow fences may be constructed of ties, laid in the form of worm fences.

Railway companies in Northern countries should widen their cuts or provide a slope of 4 to 1 on both sides of the cut for all cuts less than four feet deep.

In the construction of new railways or on grade revision, or trestle filling on existing railways in snow districts, the material should be taken from the side of the cuts. A steam shovel cut on each side is most effective in providing a place for snow to accumulate for ordinary snow conditions, for cuts up to 20 feet in depth.

Salt should be used on switches only during that portion of the winter when the snow melts in daytime and freezes at night.

Where exhaust steam is available, it should be carried about 12 inches below the surface of the ground at points where the accumulation of the ice requires frequent removal during the winter.

Snow Plows.

Rotary snow plows are necessary for quick removal of snow where the depth of the drift exceeds 6 feet and its length exceeds 300 feet or where the natural snow fall has filled deep cuts which cannot be removed by the push plow. Rotary snow plows are sometimes used to advantage in the removal of snow slides in mountain districts.

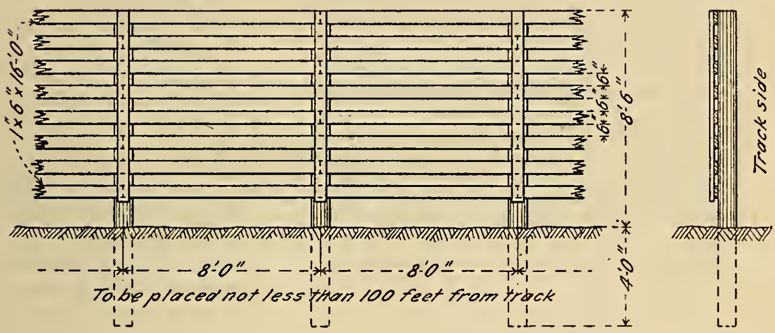
Push plows should be used for a level fall of snow and minor drifts, whenever the depth is too great to be removed by snow flangers. Snow flangers should be used for the removal of snow where the depth is less than 6 inches over the top of the rail.

SNOW SHEDS.

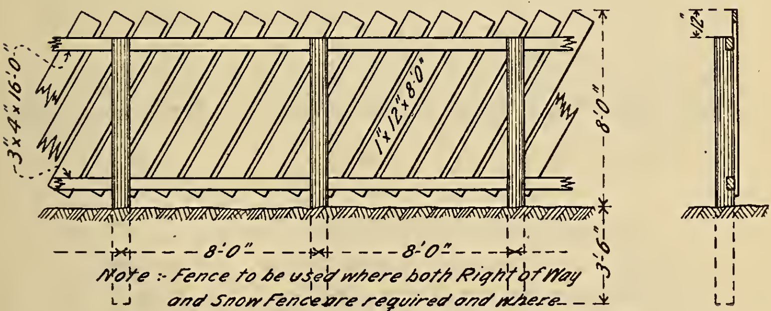
Snow sheds are expensive to construct and maintain, and the railway should be so located, if possible, as to make their construction unnecessary. Their use should be confined to localities which require protection from mountain snow slides, and they should be constructed of permanent material.

PERMANENT SNOW FENCE.

OPEN BOARDING.

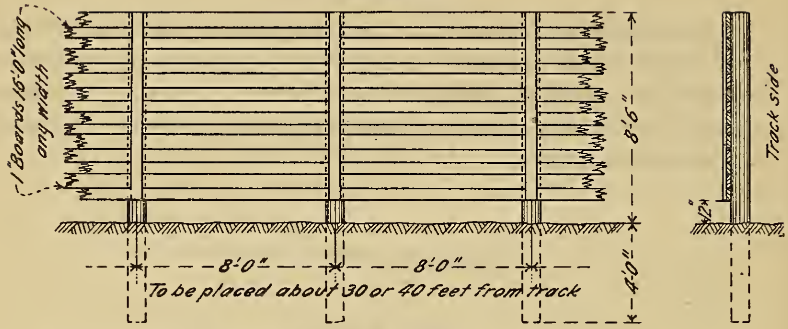


To be placed not less than 100 feet from track

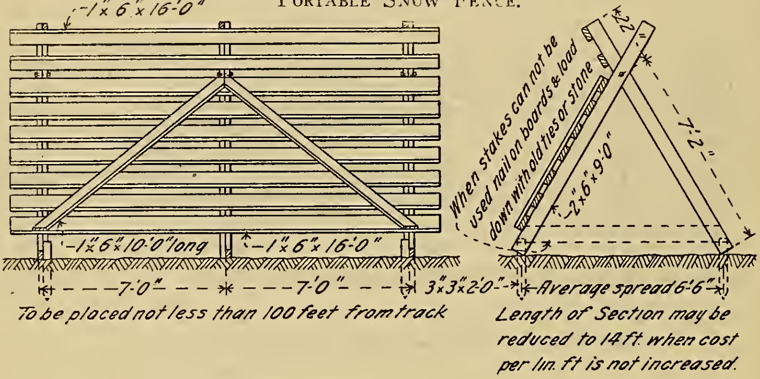


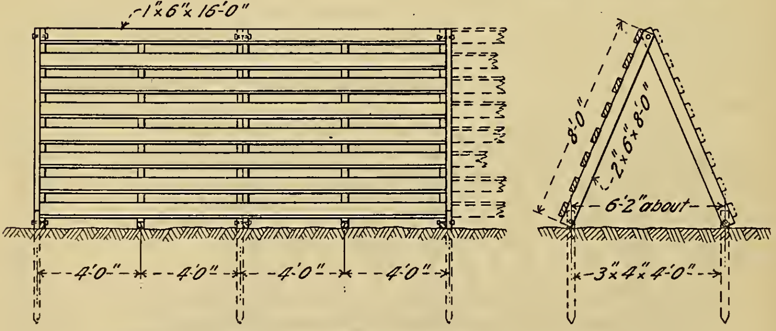
Note :- Fence to be used where both Right of Way and Snow Fence are required and where the Right of Way width is such that the Permanent form will be effective.

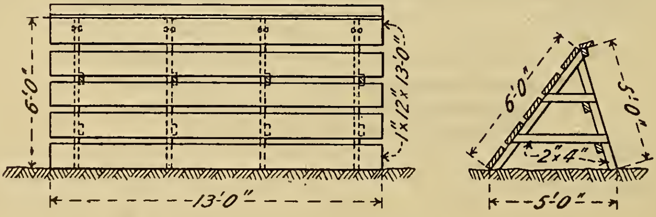
CLOSE BOARDING.


1" Boards 16'-0" long any width
8'-6"
4'-0"
8'-0"
8'-0"
To be placed about 30 or 40 feet from track
Track side
12"

PORTABLE SNOW FENCE.


1" x 6" x 16'-0"
1" x 6" x 10'-0" long
1" x 6" x 16'-0"
7'-0"
7'-0"
3" x 3" x 2'-0"
To be placed not less than 100 feet from track
When stakes can not be used nail on boards & load down with old ties or stone
2" x 6" x 9'-0"
2'-2"
7'-2"
Average spread 6'-6"
Length of Section may be reduced to 14 ft. when cost per lin. ft. is not increased.





[7] WOODEN CROSSING SIGNS.

The crossing sign should be made with wooden blades 12 inches wide and 8 feet long, with mitred ends, placed diagonally at an angle of 50 degrees between blades on an 8-inch by 8-inch by 16-foot wooden post. The post should stand 4 feet in the ground. The lower 9 feet of post should be painted black, and the balance white. The blades should be painted white with black letters and one-half inch black border around blades. Border and lettering should be on both sides. Letters should be Egyptian style, 9 inches high, with the exception of connecting terms, as "for the" in the recommended sign, which should be 4 inches high.

[8] TRESPASS SIGNS.

Trespass signs should be made of cast-iron ¼ inch in thickness. borders to be raised ⅛ inch, with slight draught; they should be 1 foot 6 inches deep by 2 feet 6 inches wide, with ⅜-inch diagonal cast ribs on back for stiffness; all signs to have face of letters and borders painted black on white backgrounds; posts and back of signs to be painted black, letters to be raised ⅛ inch with slight draught; 2½-inch wrought-iron pipe, or good second-hand boiler tubes, filled with grout to be used for posts. When concrete or stone foundations are not used, the pipe is to be planted 3 feet 6 inches deep in the ground and a 1-inch diameter gas pipe about 18 inches long to be run through the pipe post about one foot below ground line to keep it from turning. The wording indicated on typical signs, "RAILROAD PROPERTY—TRESPASSING FORBIDDEN UNDER PENALTY OF THE LAW," or "DANGER—DO NOT TRESPASS ON THE RAILROAD," is suggested.

[9] ROADWAY INFORMATION SIGNS.

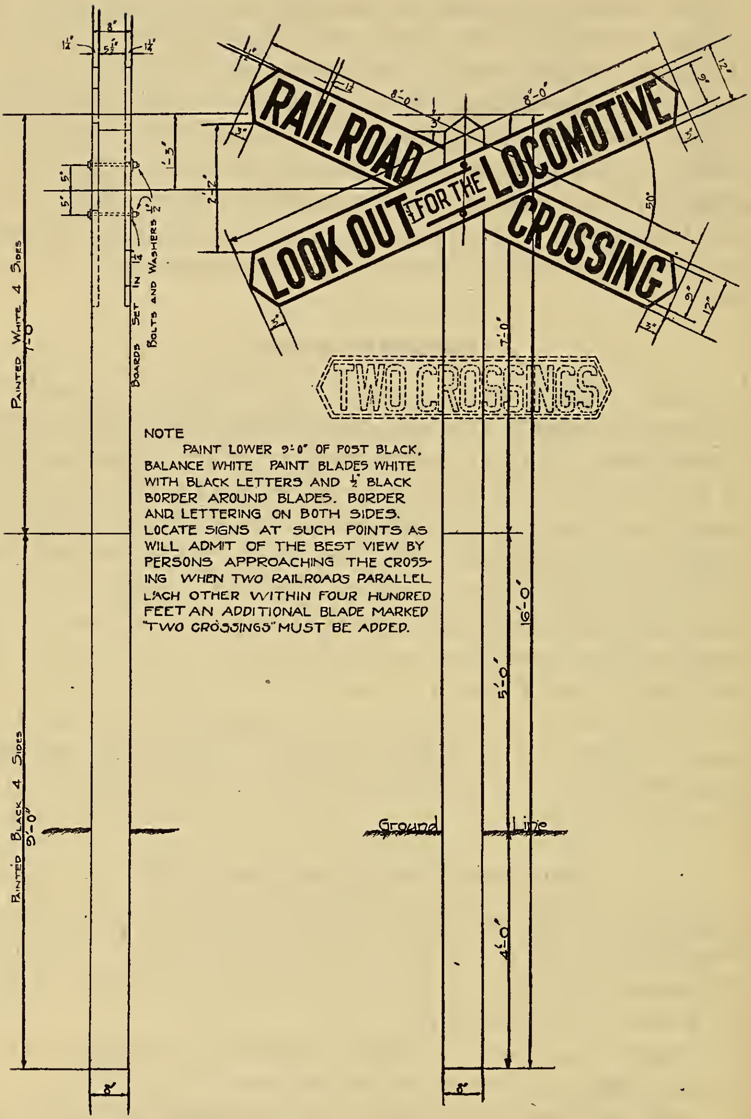
Signs for Dump Ashes, Blind Siding, Water Station, Fuel Station, Beginning of Double Track, End of Double Track, End of Block, Lack of Clearance, Corporation or Sub-division and Passing Siding to be similar to sketch for Trespass Signs.

Length of sign plate to be changed, if necessary, on account of wording and corners to be square on last two signs.

NOTE.—In general, the cast-iron plates are intended for use with the more permanent signs, or on those roads where it is believed the additional cost of the cast-iron plates is justified.

---

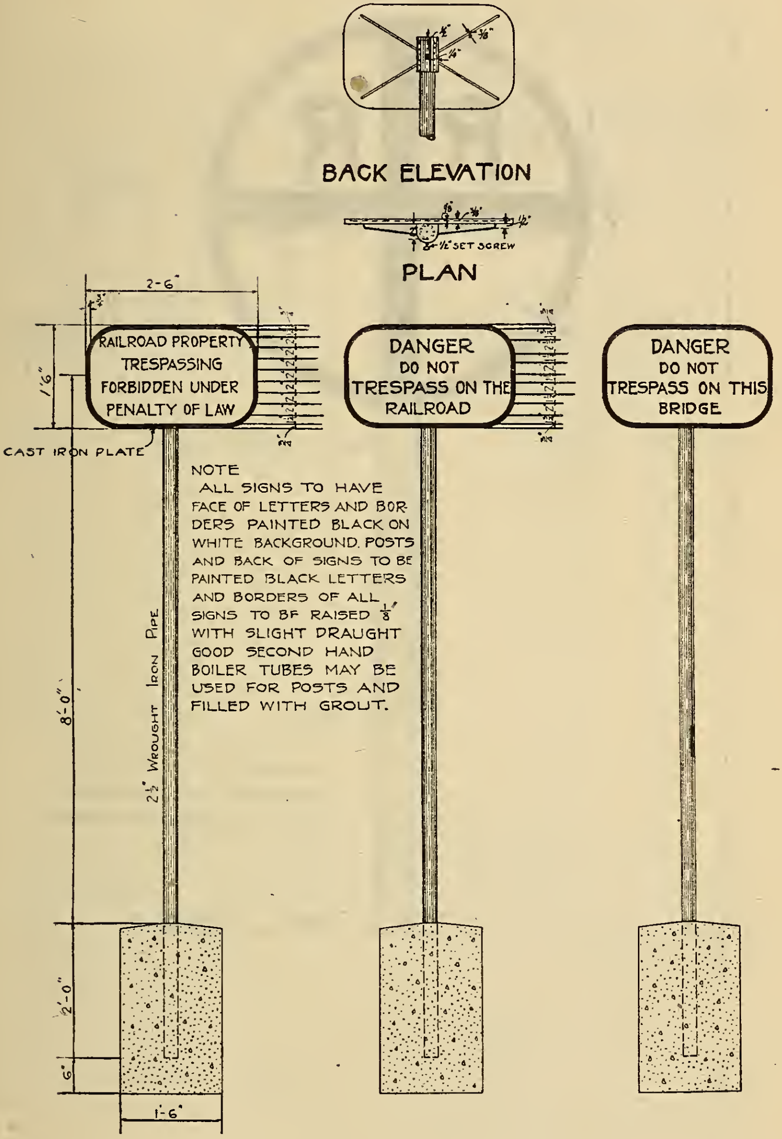
[7] Adopted, Vol. 15, 1914, pp. 872-873, 1137-1148.
[8] Adopted, Vol. 15, 1914, pp. 880, 881, 1148-1150.
[9] Adopted, Vol. 22, 1921, pp. 268, 997.



NOTE
PAINT LOWER 9'-0" OF POST BLACK, BALANCE WHITE PAINT BLADES WHITE WITH BLACK LETTERS AND ½" BLACK BORDER AROUND BLADES. BORDER AND LETTERING ON BOTH SIDES. LOCATE SIGNS AT SUCH POINTS AS WILL ADMIT OF THE BEST VIEW BY PERSONS APPROACHING THE CROSSING WHEN TWO RAILROADS PARALLEL EACH OTHER WITHIN FOUR HUNDRED FEET AN ADDITIONAL BLADE MARKED "TWO CROSSINGS" MUST BE ADDED.

Crossing Sign.

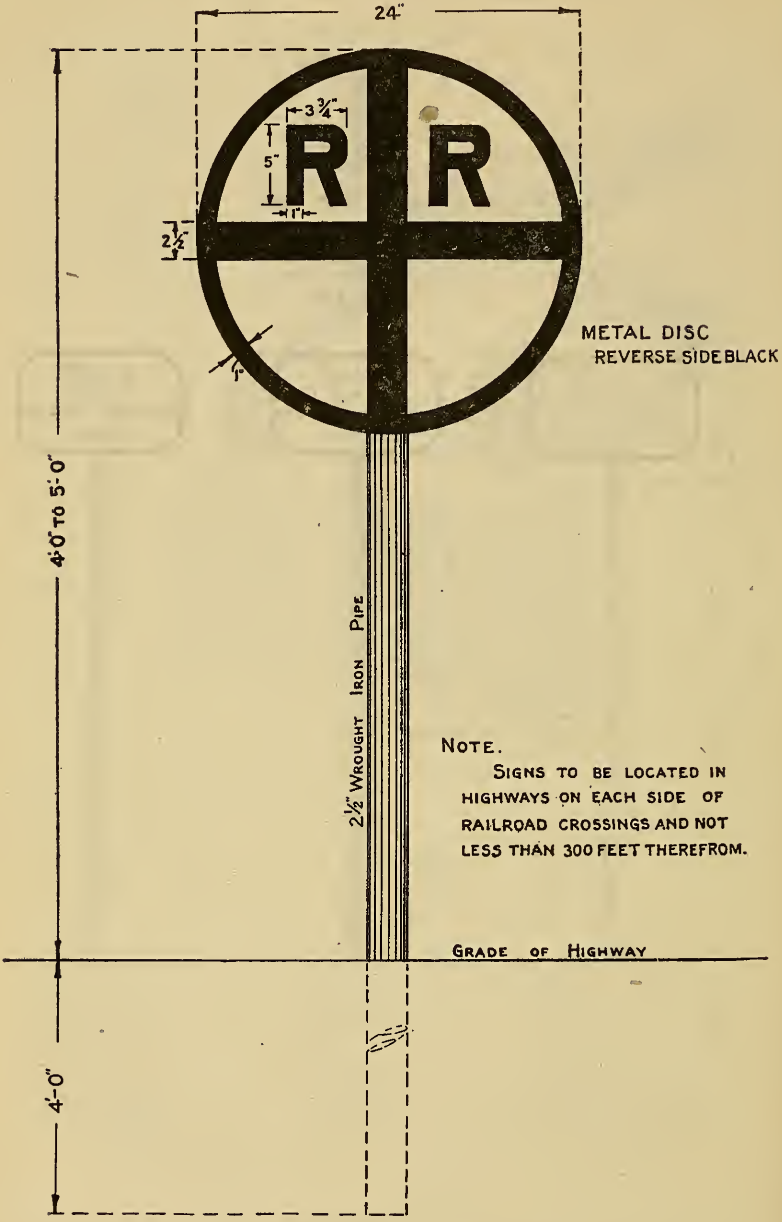
Note.—Lettering on Crossing Sign is suggestive only, and should conform to local conditions.



NOTE
ALL SIGNS TO HAVE FACE OF LETTERS AND BORDERS PAINTED BLACK ON WHITE BACKGROUND. POSTS AND BACK OF SIGNS TO BE PAINTED BLACK. LETTERS AND BORDERS OF ALL SIGNS TO BE RAISED $\frac{1}{8}$" WITH SLIGHT DRAUGHT. GOOD SECOND HAND BOILER TUBES MAY BE USED FOR POSTS AND FILLED WITH GROUT.

Trespass Signs.

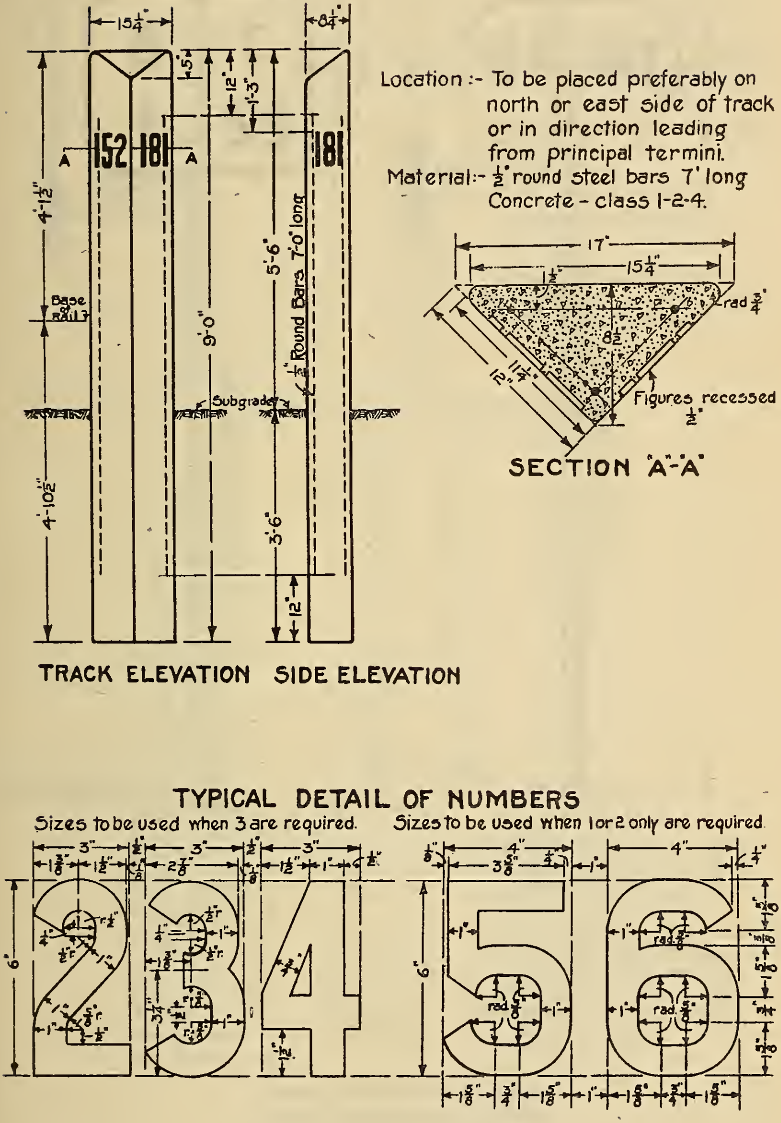
Note.—Lettering on Trespass Sign is suggestive only, and should conform to local conditions.



Note.

Signs to be located in highways on each side of railroad crossings and not less than 300 feet therefrom.

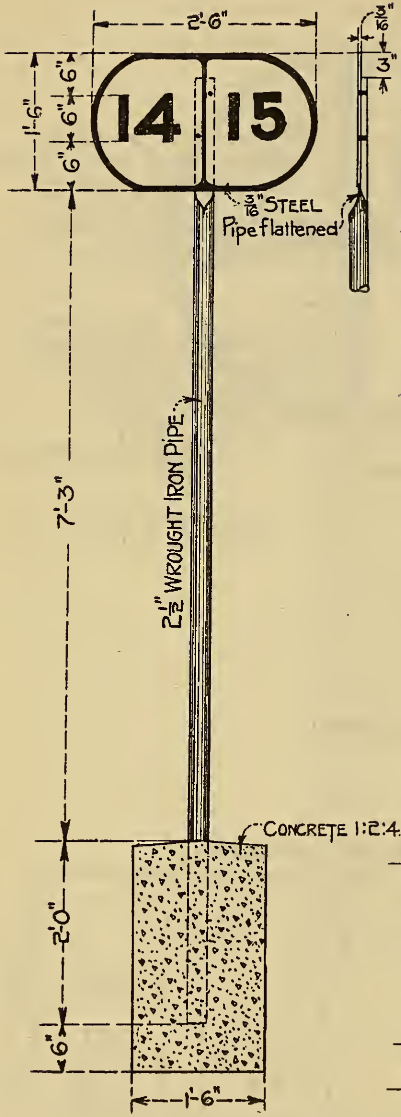
Approach Warning Sign.

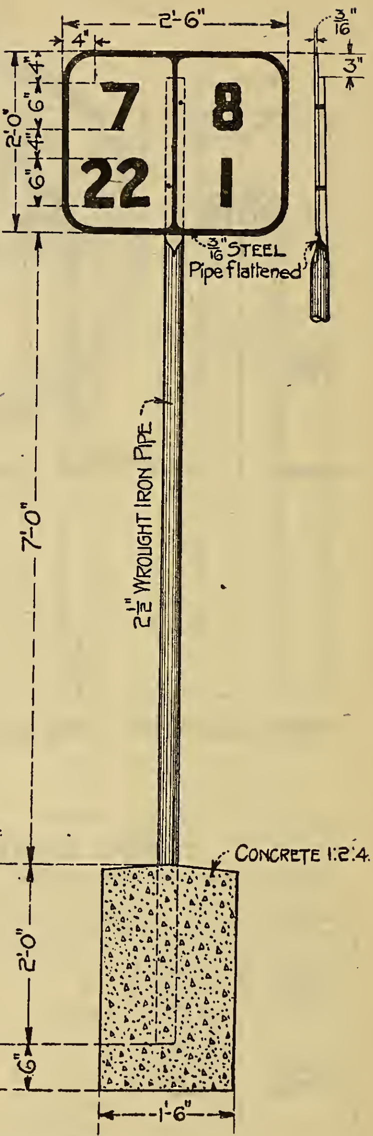


Location :- To be placed preferably on north or east side of track or in direction leading from principal termini.

Material:- ½" round steel bars 7' long
Concrete - class 1-2-4.

Mile Post.

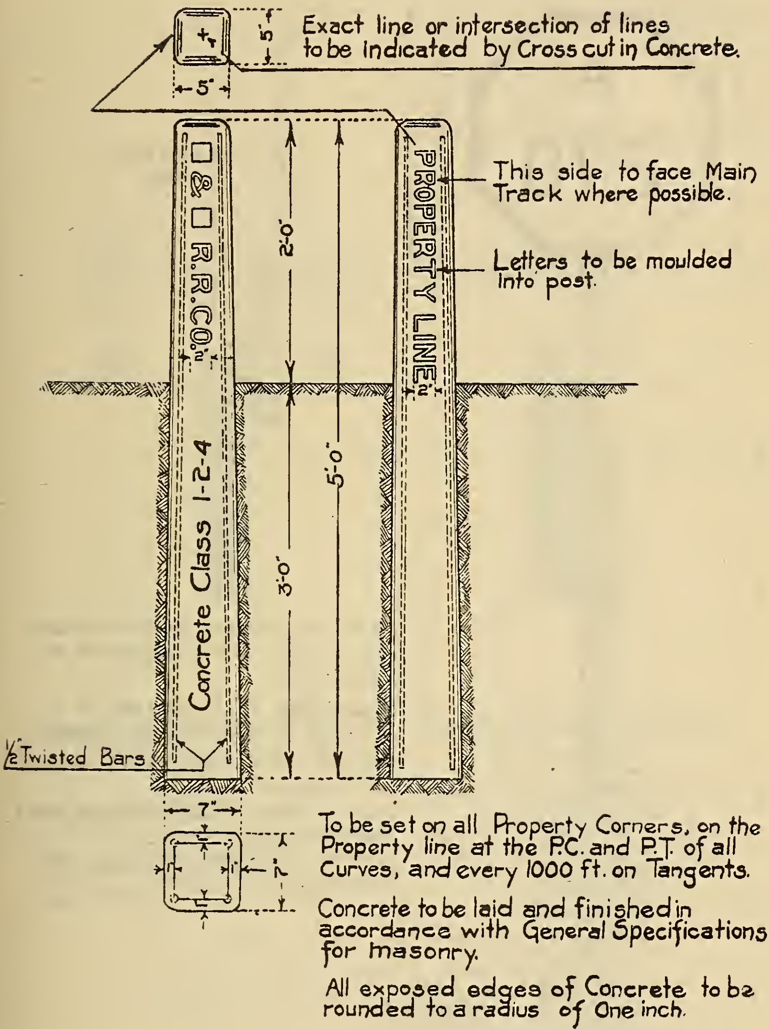




SIGNS TO HAVE 1" BLACK MARGIN,
WHITE FIELD AND BLACK LETTERS.
PLACE SIGN PARALLEL TO TRACK
NEAR RIGHT OF WAY LINE.

SECTION POST.

SUB DIVISION AND SECTION POST.



Exact line or intersection of lines to be Indicated by Cross cut in Concrete.

This side to face Main Track where possible.

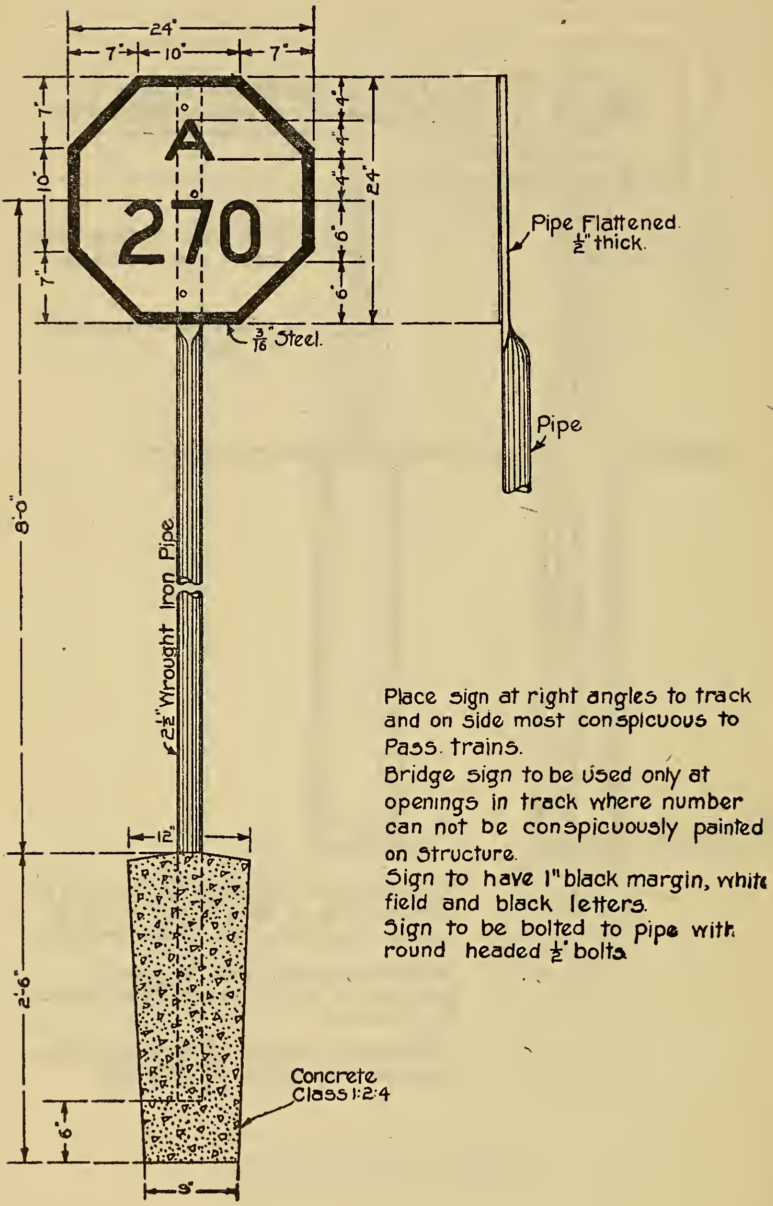
Letters to be moulded into post.

To be set on all Property Corners, on the Property line at the P.C. and P.T. of all Curves, and every 1000 ft. on Tangents.

Concrete to be laid and finished in accordance with General Specifications for masonry.

All exposed edges of Concrete to be rounded to a radius of One inch.

Property Line Post.



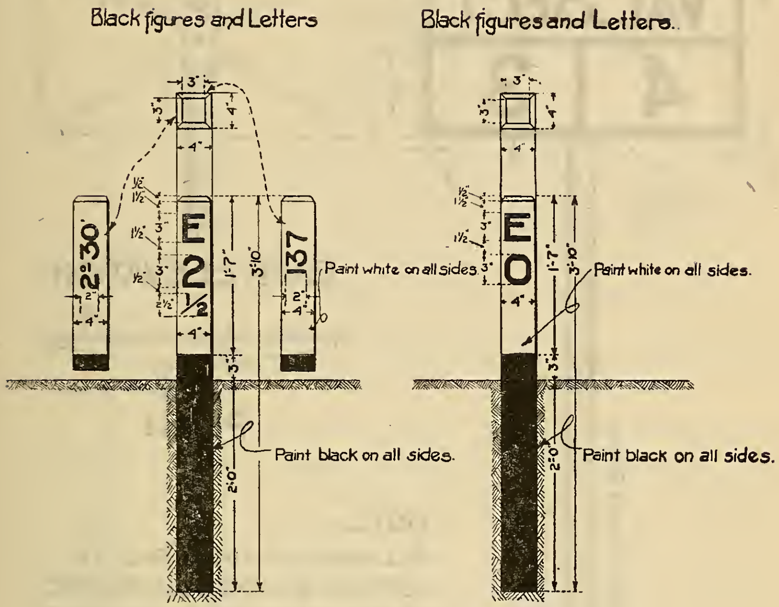
Place sign at right angles to track and on side most conspicuous to Pass. trains.

Bridge sign to be used only at openings in track where number can not be conspicuously painted on structure.

Sign to have 1" black margin, white field and black letters.

Sign to be bolted to pipe with round headed ½" bolts.

BRIDGE SIGN.


Black figures and Letters
Black figures and Letters.
3"
4"
3"
4"
½"
1½"
1½"
3"
½"
2½"
E
2
½
2° 30'
2"
4"
137
1'-7"
3'-10"
3"
2'-0"
Paint white on all sides.
Paint black on all sides.
E
O
Paint white on all sides.
Paint black on all sides.

FULL ELEVATION POST

SINGLE TRACK

Set on inside of curve at each end 7'-0" from gauge side of near rail to near side of post and opposite "End of Easement" in all cases. Elevation to read approaching curve. Degree of Curve to be on side facing track, and number of Curve to be on side opposite Elevation.

ZERO ELEVATION POST

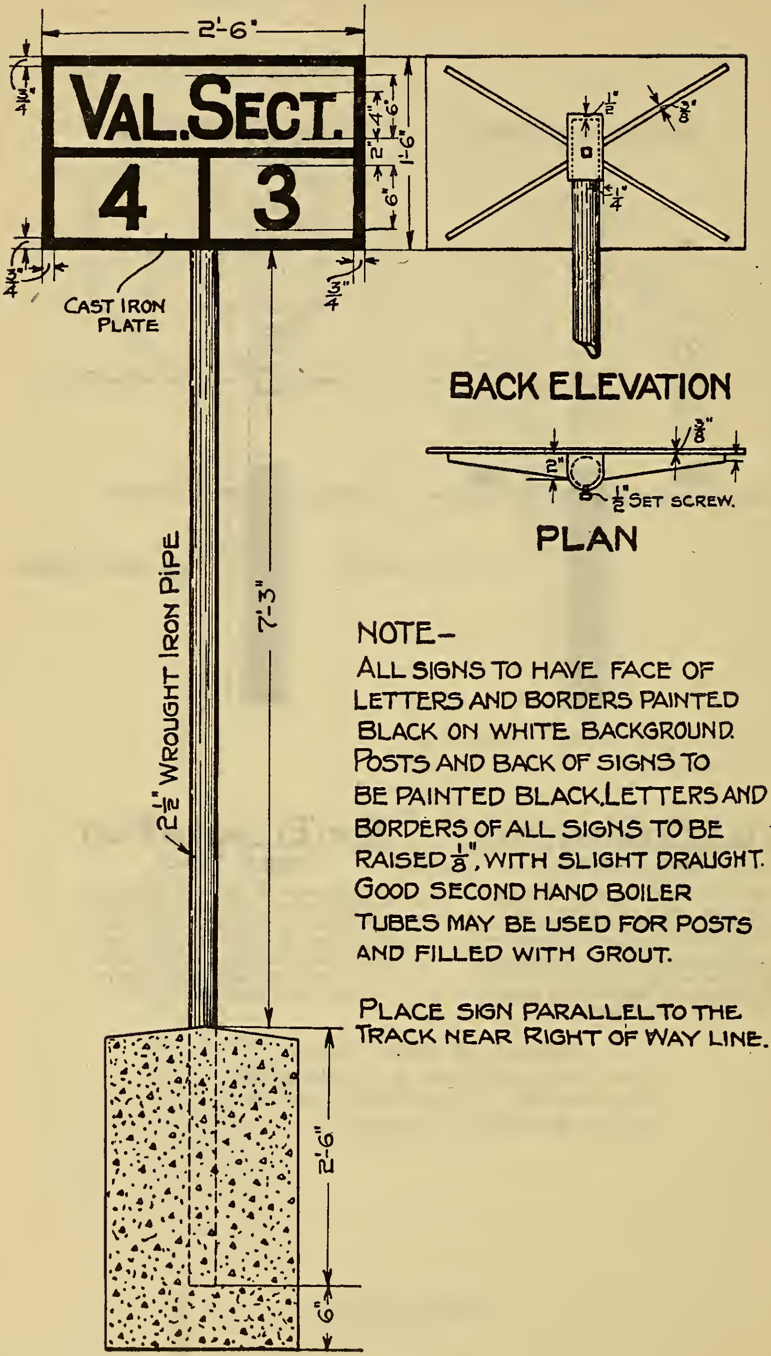
SINGLE TRACK

Set on inside of curve at each end 7'-0" from gauge side of near rail to near side of post and opposite Beginning of Easement, or where no Spiral is used at the point of run-off on tangents. Figures to read approaching Curve.

DOUBLE OR FOUR TRACK

Above notes apply also to Double or Four Track except, that all posts must be set on outside of Tracks.

Elevation Posts.



NOTE-

ALL SIGNS TO HAVE FACE OF LETTERS AND BORDERS PAINTED BLACK ON WHITE BACKGROUND. POSTS AND BACK OF SIGNS TO BE PAINTED BLACK. LETTERS AND BORDERS OF ALL SIGNS TO BE RAISED 1/8", WITH SLIGHT DRAUGHT. GOOD SECOND HAND BOILER TUBES MAY BE USED FOR POSTS AND FILLED WITH GROUT.

PLACE SIGN PARALLEL TO THE TRACK NEAR RIGHT OF WAY LINE.

Valuation Section Sign.

COMMITTEE X.

SIGNALS AND INTERLOCKING.

[1] DEFINITIONS.

Definitions from Standard Code of The American Railway Association.

Block.—A length of track of defined limits, the use of which by trains is controlled by block signals.

Block Station.—A place from which block signals are operated.

Fixed Signal.—A signal of fixed location, indicating a condition affecting the movement of a train.

Block Signal.—A fixed signal controlling the use of a block.

Home Block Signal.—A fixed signal at the entrance of a block, to control trains in entering and using said block.

Distant Block Signal.—A fixed signal used in connection with a home (and advance) block signal, to regulate the approach thereto.

Advance Block Signal.—A fixed signal used in connection with a home block signal to subdivide the block in advance.

Block System.—A series of consecutive blocks.

Manual Block System.—A block system in which the signals are operated manually.

Controlled Manual Block System.—A block system in which the signals are operated manually, and so constructed as to require the coöperation of the signalmen at both ends of the block to display a clear or a caution block signal.

Automatic Block System.—A block system in which the signals are operated by electric, pneumatic, or other agency actuated by a train or by certain conditions affecting the use of a block.

---

[1] Adopted, Vol. 7, 1906, pp. 482, 522-524.

Absolute Block System.—One in which only one train at a time is permitted to occupy this block.

Arm Sweep.—The segment of a circle defining the limits of movement of the arm.

Arm.—A movable arm pivoted to the signal mast, the positions of which give the indications.

Blade.—That part of the arm which, by its form and positions, gives the day signal indications.

Bracket Mast.—A mast mounted on a bracket post.

Bracket Post.—An arrangement of main post with cross-beam, upon which is placed one or two masts for carrying the signal arms, the arrangement of masts determining which track or tracks the signals govern.

Bridge Mast.—A mast mounted on a signal or other overhead bridge.

Chain Wheel.—A device used for changing the direction of a wire line.

Compensator.—A device placed in a pipe or wire line for automatically maintaining a constant length of line under changes of temperature.

Crank.—A device used for changing the direction of a pipe line.

Crank Stand.—A frame in which cranks are supported.

Cross Locking.—A variable shaped block or bar running crosswise of the interlocking machine, actuated by the movements of the locking dog, and by means of which connection is effected between the levers.

Detector Bar.—A bar placed at a switch alongside of and normally below the top of rail, operated in connection with a facing point lock, derailing device or crossing switch, or so that its operation, and consequently that of the lock, will be prevented by the presence of any of the wheels of the train.

Electric Slot.—An appliance for automatically disengaging the signal arm connection from its actuating lever, returning signal arm to "Stop."

Foundation.—A fixed support, usually set in the ground, for carriers, cranks, compensators, wheels, signals and other like devices.

Interlocking Machine.—The primary operating or controlling mechanism of an interlocking plant, placed in the interlocking station, and in which the interlocking feature is effected.

Interlocking Plant.—An arrangement of switch, lock and signal appliances so interconnected or interlocked that one movement must succeed another in a predetermined order.

Interlocking Signals.—The fixed signals of an interlocking plant.

INTERLOCKING STATION.—A place from which an interlocking plant is operated.

JAW.—A device attached to pipe line for connecting same with machine, crank, compensator, or any other device designed for pipe operation.

LEADOUT.—A combination of cranks, wheels, rocking shafts, pipes and wire, etc., inside and outside of interlocking station by which connections are made between machine and pipe runs.

LEVER.—That part of an interlocking machine whose movement effects the operation of its function.

LOCKING.—A combination of locking dogs and cross-locking or locking dogs and tappets by means of which interconnection is effected between the levers and the order of movement determined.

LOCKING BAR.—A bar running lengthwise in the interlocking machine to which the locking dogs are attached.

LOCKING DOG.—A variously shaped block attached to locking bar and through which the interlocking is accomplished.

MAST.—The upright to which the signals are directly attached.

OPERATED UNIT.—A switch, signal, lock or other device in signaling, operated by a lever or other operating means.

PERMISSIVE BLOCK SYSTEM.—One in which two or more trains may occupy a block at the same time.

PIPE CARRIER.—A frame with roller support for the pipe line.

PIPE RUN.—An assemblage of pipe lines of an interlocking plant, with their carriers and foundations, in a common course.

ROCKING SHAFT.—A rotating shaft with arms, used for changing the line of motion from one plane to another, perpendicular to the axis of the shaft; also used at slip switches for operating several detector bars and locks.

ROUTE.—A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, or any one of several possible combinations of turnouts or crossovers by which a train may travel between two places.

SCREW JAW.—A threaded jaw used for the purpose of adjustment.

SEMAPHORE SIGNAL.—A device consisting of a movable arm attached to a mast, the indications being given by the position of the arm.

SEMAPHORE SPECTACLE.—That part of a signal which holds the colored glasses and to which the blade may be attached.

TAPPET.—*a.* (In machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them.

b. (In machine with horizontal locking.) A pivot or swing dog attached to the locking bar, and actuated or locked by the cross-locking.

Wire Carrier.—A frame with roller support for the wire line.

Wire Run.—An assemblage of wire lines of an interlocking plant, with their carriers and foundations, in a common course.

[2] CONVENTIONAL SIGNS OR SYMBOLS FOR SIGNALS AND INTERLOCKING.

(See under Records and Accounts, 13 Plates, latest R. S. A. Drawings.)

[3] TRAIN-ORDER SIGNALS.

The American Railway Association's third and fourth requisites of installation of interlocking plants are: (3) "Signals if practicable (to be) either over or upon the right of and adjoining the track to which they refer." (4) "Semaphore arms that govern (to be) displayed to the right of the signal mast as seen from an approaching train."

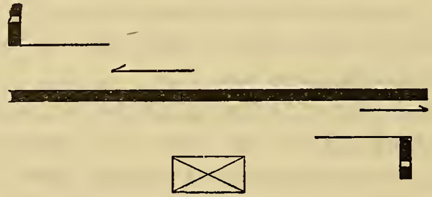


Fig. 1.

It is recommended that these two requisites be adopted with reference to *fixed* train-order signals for all number of tracks from one up, as illustrated in Figs. 1 and 2.

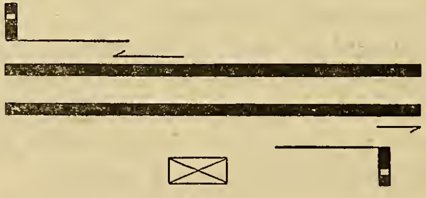


Fig. 2.

---

[2] Adopted, Vol. 15, 1914, pp. 80-92, 1010.
[3] Adopted, Vol. 4, 1903, pp. 295-297, 299, 315-346.

Where it may be deemed advisable, for special reasons, to use a bracket post, no more than two uprights should be placed on the bracket. One of these uprights may be a stub to indicate a track not signaled. In other words, no more than one track should intervene between a bracket signal post and the track for which its left upright carries the signal arm. (See Fig. 3.)

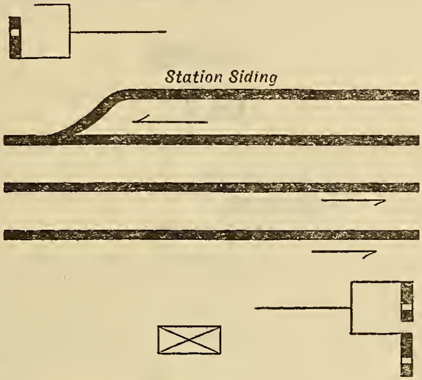


Fig. 3.

It seems proper to recognize the current practice of using flags by day and hand lamps by night. It is important, though, that a regular place for displaying these be predetermined, and there seems to be no better way than to place a regular flag socket with hook on the side of the signal station toward the direction of the approaching train, and convenient for the operator to reach from one of the windows.

The definition of "Train-Order Signal" is as follows: "A fixed signal of two indications, which in the stop position informs the engineman and conductor that they are to receive orders at the telegraph office, and in the clear position announces that there are no orders for them."

A fixed train-order signal, with a sweep of arm of 90 degrees from the horizontal, is recommended as good practice.

[4] MANUAL AND CONTROLLED MANUAL BLOCK SIGNALS.

(1) The location recommended for the Manual and Controlled Manual Block Signal is on a mast alongside and to the right of the track on which are run the trains that it governs, as shown in Fig. 4; but, in the case of more than two tracks, when it is impracticable to

---

[4] Adopted, Vol. 6, 1905, pp. 518, 527, 550, 551.

spread them apart for this purpose, then the recommended location is on a bracket post, as in Fig. 5, or on a bridge over the tracks, as in Fig. 6.

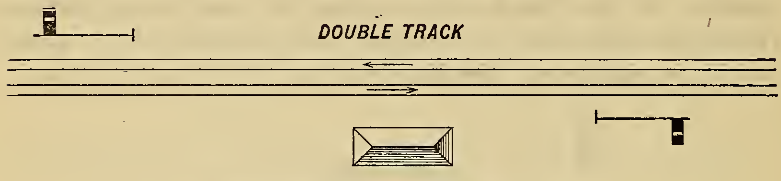


Fig. 4.

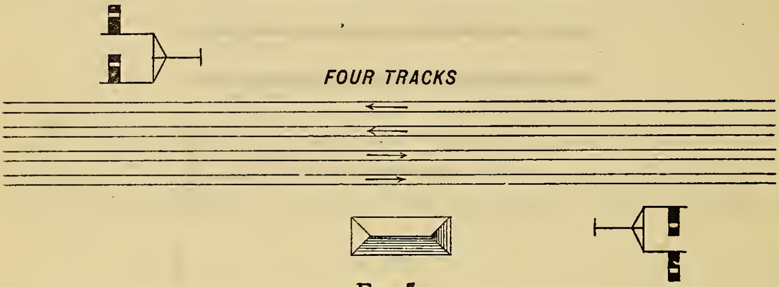


Fig. 5.

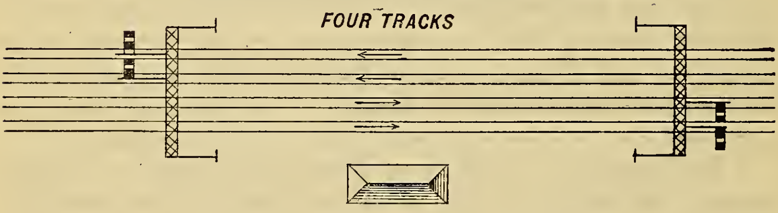


Fig. 6.

(2) It is good practice to make use of the electric slot to send the block signal to normal position, "Stop," as the train passes.

[5] LOCATION OF MANUAL BLOCK SIGNALS.

(1) The arrangement shown in Fig. 7 is good practice for use on single-track line as a train-order signal and a block signal. Distant signals may be used.

---

[5] Adopted, Vol. 7, 1906, pp. 481, 482, 485, 539, 540.

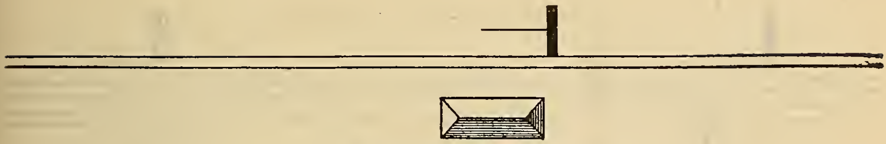


Fig. 7.

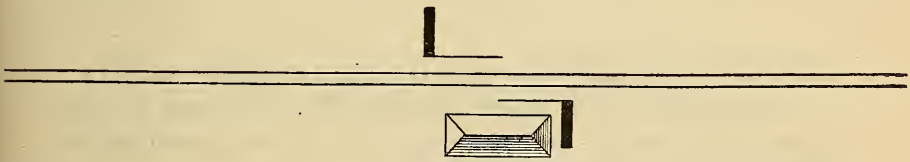


Fig. 8.

(2) The arrangement shown in Fig. 9 should be adopted when necessary to subdivide the block, and track circuit should be used in the subdivided block to control the rear signal.

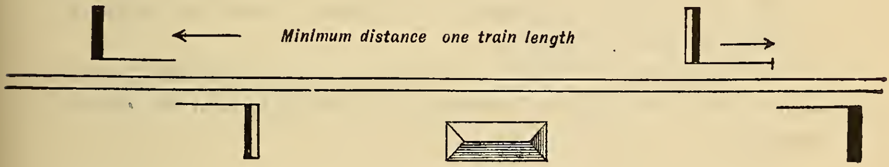


Fig. 9.

(3) The double-track arrangement, as shown in Figs. 10 and 11, is recommended as good practice.

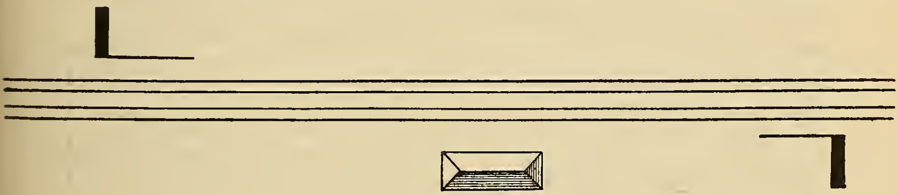


Fig. 10.

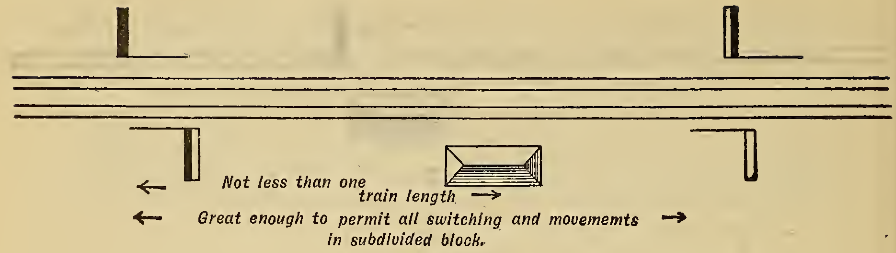

Not less than one train length
Great enough to permit all switching and movememts in subdivided block.

FIG. 11.

[6] INDICATIONS CONFERRING OR RESTRICTING RIGHTS.

The adoption of the following principles is recommended in view of the recent trend of the development of the art, and should not be understood as condemning present practice.

(1) It is recommended that the following principles of giving indications govern in formulating a signal system:

(a) That on all signals conferring or restricting rights, a red light shall be the night indication for "stop;" a yellow light shall be the night indication for "caution;" and a green light the night indication for "clear."

(b) That the day indication of semaphore signals be given in the upper right-hand quadrant.

(c) That the semaphore arm horizontal shall indicate "stop;" inclined upward 45 degrees, "caution;" and inclined upward 90 degrees, "proceed."

[7] DIVISION OF EXPENSE OF INSTALLATION, RENEWAL AND MAINTENANCE OF JOINT INTERLOCKING PLANTS.

The division of expense of the installation, renewal and maintenance of joint interlocking plants should be divided on a unit basis according to the following table:

Name of Operated Unit.	*Value.*
One Signal Arm	1
One Pair Switch Points	1
One Derail	1
One Pair Movable Point Frogs	1

---

[6] Adopted, Vol. 8, 1907, pp. 84, 97, 104.
[7] Adopted, Vol. 8, 1907, pp. 72, 84, 91-95.

One 50-ft. Detector Bar, with or without Locks	1
One Scotch Block	1
One Torpedo Machine	1
One Power Signal	1
Electric Locking.	
For Each Electric Lock	1
Annunciators and Indicators.	
One Route	1

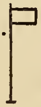
[8] SIGNAL INDICATIONS AND ASPECTS.

MEANS OF DESIGNATING STOP SIGNALS OPERATED UNDER AUTOMATIC BLOCK SYSTEM RULES.

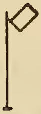
Scheme No. 1.

FUNDAMENTALS.

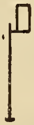
1. Stop..............................



2. Proceed with caution..................



3. Proceed.............................



As means of designating stop signal operated under automatic block system rules, the following are suggested:

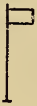
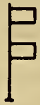
1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades or other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

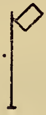
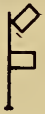
---

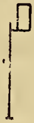
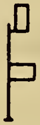
[8] **Adopted, Vol. 14, 1913, pp. 71-75, 1046.**

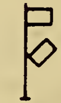
Scheme No. 2.

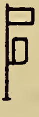
Fundamentals. Supplementary Indications.

1. Stop........................... ...  .... 

2. Proceed with caution................  .... 

3. Proceed....... ....  .... 

4. Proceed at low speed.................................. 

5. Proceed at medium speed................................ 

As means of designating stop signals operated under automatic block system rules, the following are suggested:

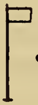
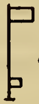
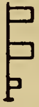
1. The use of a number plate; or

2. The use of a red marker light below and to the left of the active light; or

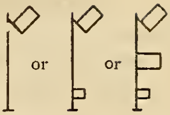
3. The use of a pointed blade, the blades of other signals giving the stop indication, having square ends; or

4. A combination of these distinguishing features.

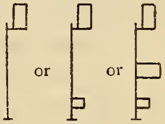
Having in view the practice of indicating diverging routes by several arms on the same mast, the following, to establish uniformity in this practice, is recommended:

1. Stop..  or  or  or

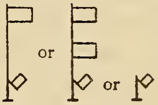
2. Proceed with caution........................



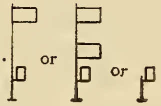
3. Proceed...



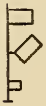
4. Proceed with caution on low-speed route......



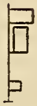
5. Proceed on low-speed route...................



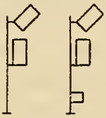
6. Proceed with caution on medium-speed route..



7. Proceed on medium-speed route..............



8. Reduce to medium speed.....................



As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or

2. The use of a red marker light below and to the left of the active light; or

3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or

4. A combination of these distinguishing features.

[9]REQUISITES OF SWITCH INDICATORS.

Purposes.

1. Switch indicators are recognized as an adjunct of the automatic block system. They may be arranged to indicate one or more of the following:

(a) Whether or not a train is approaching.

(b) Whether or not that portion of the block between the switch and the next Home Block Signal in advance is clear.

(c) Whether or not the next Home Block Signal in the direction of approaching trains is at stop.

In the Standard Code of the American Railway Association, switch indicators are placed among the adjuncts of the automatic block system: "(C) Indicators at main track switches." It is recommended that the purposes for which switch indicators may be used, and their location and control, be specified by amplification of adjunct (C) and the addition of requisites of installation, as follows:

(C) Indicators at main track switches to indicate, on roads of two or more tracks, one or more of the following:

(a) Whether or not a train is approaching.

(b) Whether or not that portion of the block between the switch and the next Home Block Signal in advance is clear.

(c) Whether or not the next Home Block Signal in the direction of approaching trains is at stop.

2. In a system equipped with switch indicators, indicators are unnecessary, and may therefore be omitted, at certain switches where signals are so located and controlled that the indications which would be given by the switch indicators can be obtained from the aspects of the signals.

Requisites of Installation.

1. Switch indicators located preferably:

(a) At main track switches connecting with tracks on which trains may clear main track and in which either there are no derails or diverging switches, or the derails or diverging switches are connected with the main-track switches.

(b) At independently operated derails or diverging switches in tracks on which trains may clear main tracks.

(c) At points from which switches of crossovers between main tracks are operated, or locked, where both switches are operated or locked from the same point.

---

[9]Adopted, Vol. 18, 1917, pp. 89, 91, 1441.

(d) At independently operated switches of crossovers between main tracks, the indicator at the switch in one track operated in connection with the other track.

2. A switch indicator for each direction where indications relating to traffic in both directions on the same track are to be given.

3. Switch indicators that cannot be identified by their locations, marked with the designations of the tracks or the directions of traffic in connection with which they are operated.

4. (a) The connections of switch indicators used to indicate whether or not a train is approaching, so arranged that an indicator will indicate the approach of a train that has reached a point at least such a distance in the rear of the second block signal in the direction of approaching trains, that if the switch is thrown at the moment when a train reaches that point, the Caution signal will be displayed in time to be observed by the engineman, and will continue so to indicate until the train passes the Home Block Signal in the rear of the switch or, approximately, the clearance point of the switch when the switch is more than..........feet in advance of the Home Block Signal. The distance of the point at which the approach of a train is first indicated will be determined in each case by the grade, speed of trains, view of the signal or other local conditions.

(b) Equivalent control of signals certain aspects of which serve, in lieu of switch indicators, to indicate whether or not a train is approaching.

[10] LIST OF THE FINDINGS, CONCLUSIONS, STANDARDS AND SPECIFICATIONS CONTAINED IN THE MANUAL OF THE RAILWAY SIGNAL ASSOCIATION.

(Published for the information of the members of the American Railway Engineering Association.)

EXHIBIT "A"

SPECIFICATIONS.

Abbreviations.
Alternator.—Specification.
Annunciators.—See Bells.
Automatic Block Signals.
  Alternating Current.—A. C. Propulsion, Specifications.
  Alternating Current.—D. C. Propulsion, Specifications.
  Alternating Current.—Steam Railways, Specifications.
  Direct Current.—Specifications.
Automatic Signal Systems.—See Overlaps.
Automatic Train Control.
  Requisites of Installation and Adjuncts. (A.R.A.)—See Train Control.

---

[10] Adopted, Vol. 21, 1920, pp. 841, 1445.

Battery, Primary.
  Caustic Soda Primary Cell.—Specifications.
  Caustic Soda.—Instructions for Installation and Handling.
  Coppers.—Gravity Battery, Specifications.
  Jars, Specification.
  Jar.—See Drawings 1053 and 1189.
  Zinc.—Gravity Battery, Specification.
Battery, Storage.
  Concrete Box, Specification.
  Lead Type, Instructions for Operation. (Charged from primary cells.)
  Lead Type, Electrolyte for, Specification.
  Lead Type, Directions for Installation.
  Lead Type, Instructions for Operation of, at Interlockings.
  Lead Type, Instructions for Block Signal Service. (Line charging.)
  Nickel, Iron, Alkaline, Specification.
  Nickel, Iron, Alkaline, Instructions for Maintenance.
  Portable Lead Type, Directions for Installation.
  Portable Lead Type, Instructions for Operation.
  Portable Lead Type, Specifications.
  Stationary Composite Type, Specification.
  Stationary Pure Lead Type, for Signaling, Specification.
  Stationary.—(Not of the Pure Lead Type), Specification.
  Stationary, Lead Type, Direction for Installation.
Bells.
  Annunciator, Specification.
  Highway Crossing, D. C. Vibrating, Specification.
Bridges, Movable, Protection of Traffic at.
Buttons.—(See Push Buttons.)
Cables.
  Aerial Aluminum, Specification.
  Aerial Braided, for 660 Volts or less, Specification.
  Armored Submarine, for 660 Volts or less, Specification.
  Armored Submarine, for 2,200 Volts, Specification.
  Lead covered, for 660 Volts or less, Specification.
  Lead covered, for 2,200 Volts, Specification.
  Underground Braided, for 660 Volts, Specification.
Cell.—See Battery, Primary.
Channel Pins.—Specification
Circuit Nomenclature and Written Circuits.
Clearance Diagram. (The A.R.A.)
Coils and Windings.—See Impregnation Treatment, Specifications.
Concrete.
  Box.—See Battery Storage.
  Portland Cement, Specification.
Conduit.
  Fibre, Specification.
  Fibre and Metal, Installation of a System, Specification.
  Pipe, Steel, Specification.
  Pipe, Wrought Iron, Specification.
  Vitrified Clay, Specification.
  Vitrified Clay, Installation of a System, Specification.
Copper Sulphate.—Specification.
Coppers.—See Battery, Primary.
Cross-Arms.
  Wood Specification.
  Braces and Heel and Toe Bolts for, Specification.
  Steel Pins for, Specification.
  Through Bolts and Double-arm Bolts for, Specification.

Definitions for Technical Terms.
Dielectric Requirements.—See General Electric Requirements.
Drawings.—See Standard Designs. (Separate Section.)
Engine, Gasoline, With Fuel and Water Tanks.—Specification.
Fibre, Hard.—Specification.
Floor Pushes.—See Pushes, Floor.
Forms.—For Recording Signal Performance.
Friction Tape.—See Tape.
Fuses.—Specification.
Galvanizing for Iron or Steel.—Specification. (A.R.A.)
Gasoline Engine.—See Engine.
General Electrical Requirements.
General Provisions (for use in Major Specifications).
Generators.
  Electrical, Specification.
Glass Jars.—See Drawings 1053 and 1189.
Glass Signal.—See Roundels.
Globes, Hand Lantern.—Specification.
Gray Iron Castings.—See Iron.
Highway Crossing Alarms.—See Bells.
Identification.—See General Electrical Requirements.
Impedance Bonds.
  Specification.
  Petrolatum for use in, Specification. (See Petrolatum.)
Impregnation Treatment of Coils and Windings.—Specification.
Indexes to Major Specifications.—1918-1919.
Indications, Signal, Principles of.
Indicators.
  Take Siding Indicator.
  Switch, Purpose and Requisites of Installation.
Inspection.—See Standard Sections.
Insulation.—See General Electrical Requirements.
Instructions.
  Testing and Maintaining Dry Cells.
  Maintenance of Gravity Cells.
  Maintenance of R.S.A. Caustic Soda Cells.
Instruments.
  Ranges and Scales for.
Interlocking.
  Electric, Specifications.
  Electromechanical, Specifications.
  Electropneumatic, Specifications.
  Mechanical, Specifications.
  Mechanical, Machine, Saxby and Farmer, Specification.
  Power, Machine, Specification.
  Requisites, Mechanical, Machine, Specification.
Iron.
  Castings, Gray, Specification.
  Malleable, Specification.
  Wrought Bars, Specification.
Lamps.—Incandescent Electric, Specification.
Lenses.—See Roundels.
Lightning Protection.
  Arresters, Made Ground Apparatus.
  Arresters, Requisites for.
  Choke Coils, Requisites for.
  Vacuum Gap, Specification.
Machinery Steel.—See Steel Machinery.
Markings.—See Standard Sections.

Movable Bridges, Protection.—See Bridges.
Oil.
  Illuminating, Specification.
  Transformer, Specification.
Overlaps in Connection with Automatic Signal Systems.
Packing.—See Standard Sections.
Paint and Painting.—Specification.
Performance Signal.—Forms for Recording.—See Forms.
Petrolatum.—For use in Impedance Bonds.
Petroleum Asphaltum.—Specification.
Phrases and Words.
Pins.—See Channel Pins, or Cross-arms—Steel Pins.
Pipe Compensation.—Specification.
Pipe, Signal.
  Soft Steel, One-inch, Specification.
  Wrought Iron, One-inch, Specification.
Poles, Eastern White Cedar.—Specification.
Protection of Traffic at Movable Bridges.—See Bridges.
Push Buttons.—Specifications.
Pushes, Floor.—Specification.
Reactors for Line and Track Circuits.—Specification.
Relays, Alternating Current.—Specification.
Relays, Lifting Armature, Neutral Type, D. C.—Specification.
Relays, Direct Current, Comparisons of Resistance.
Relays, Direct Current, Table of Resistance.
Releases, Mechanical and Electric.—Specification.
Resistors for Line and Track Circuit.—Specification.
Roundels, Lenses and Slides.—Specification.
Rubber Insulating Tape.—See Tape.
Rules.
  Governing Maintenance of Block Signals.
  Governing Maintenance at Interlocking Plants.
  Governing Signal Foremen.
  Governing Signal Maintainers.
  Governing Signal Supervisors.
Signs or Markers for Enginemen.
Signals, A. C. Motor Semaphore.—Specification.
Signals, D. C. Motor Semaphore.—Specification.
Signals, Electric Color Light.—Specification.
Signals, Electric Position Light.—Specification.
Signal Performance.—See Forms for Recording Signal Performance.
Signaling Practice.
  Signal Indications and Aspects. (A.R.A.)
  Signal Indications, Principles of. (See Indications.)
Standard Designs.—See Separate Section.
Standard Sections.—(For use in unit specifications.)
Steel, Machinery.—Specification.
Steel Pipe.—See Pipe.
Sulphate.—See Copper Sulphate.
Switchboards.
  Materials for.
  Requisites for.
Switch Indicators, Purpose and Requisites of Installation.
  See Indicator.
Take Siding Indicator.—See Indicator.
Tape, Friction.—Specification.
Tape, Rubber.—Specification.
Terminology, Electric Wire and Cable.
Tests.—See Standard Sections.

Train Control.—Automatic.
Transformers.
  Single-phase, Air-Cooled, Track, Specification.
  Single-phase Line, Oil Immersed, Self-Cooled, Specification.
Trunking, Wood.—Specification.
Volt-Ammeters, Portable D. C.—Specification.
Voltage Ranges for Signal Work.
Wire.
  Bonding.—Copper-clad Steel, Specification.
  Bonding.—Galvanized E. B. B., Specification.
  Line.—Copper-clad Steel, Specification.
  Line.—W.P.D.B., B.B., Specification.
  Line.—W.P.D.B., Copper, Specification.
  Magnet.—Copper Enameled, Specification.
  Messenger.—Galvanized, Specification.
  Messenger.—Recommended Sags for.
  Rubber Insulated.—Copper, Specification.
  Rubber Insulated.—Inspection Report, Form for.
  Rubber Insulated.—Insulation Resistances.
  Rubber Insulated.—Machine for Insulating, Type of.
  Signal.—Galvanized Steel, Specification.
  Stranded and Flexible Conductors, Table of.
Wire and Cable, Electric, Terminology.—See Terminology.
Wire Crossings.
  Crossings of Wires or Cables of Telegraph, Telephone, Signal and Other Circuits of Similar Character over Steam Railroad Rights of Way, Track or Lines of Wires of the same classes. Specifications. (Ass'n of Ry. Teleg. Supts.)
Written Circuits.—See Circuit Nomenclature.
Wrought Iron Bars.—See Iron.
Wrought Iron Pipe.—See Pipe.
Zincs.—See Battery, Primary.

EXHIBIT "B"

Drawing	*No.*	*Last Revision Date*
Adapter, Base for Ground Mast Bottom Mechanism Signals	1387	Sept., 1916
Adapter, Staff Tip	1459	Sept., 1919
Adjustment, Switch—		
Details	1390	Sept., 1916
Insulated	1392	Sept., 1916
Non-Insulated	1391	Sept., 1916
Anchor Posts	1058	March, 1913
Battery—		
Primary		
Copper	1088	Oct., 1913
Jars and Covers, round	1053	June, 1918
Zinc	1087	Oct., 1913
Storage		
Connection Bolt	1340	March, 1914
Jars, Covers, Hold-downs and Sand Trays	1224	Dec., 1919
Lead Elements	1241	March, 1914
Separators	1341	Sept., 1914
Battery Box—		
Primary, Concrete	1343	June, 1918
Storage, Concrete	1342	March, 1914
Battery Chutes—		
Assembly	1230	Dec., 1912
Details of Double	1229	Dec., 1912

Drawing	*No.*	*Last Revision Date*
Details of Single	1228	Dec., 1912
Elevators	1227	Sept., 1916
Binding Posts	1070	Sept., 1915
Blades—		
Signal	1065	March, 1918
Bolt Lock, Multiple Unit	1095	March, 1917
Bracket Post—		
Channel Column	1032	May, 1914
Crank Brackets for	1198	March, 1915
Deck for Pipe and Channel Columns	1030	May, 1914
Guide Clamps, Brackets and Cape for Vertical Connections	1020	March, 1915
Guides for Vertical Connections	1196	March, 1915
Hand Rail for	1179	Oct., 1912
Mechanical Connections, 6-way	1190	Oct., 1912
Mounting for Bottom Mast Mechanism Cases on	1033	Sept., 1914
Pipe—		
Base for	1038	Oct., 1913
Crank Bracket Fittings for	1024	March, 1915
Crank Bracket Fittings for	1025	March, 1915
Head and Trunking Cap	1031	May, 1914
Cable Post—		
Assembly with Relay Boxes	1185	June, 1917
Base for	1180	Oct., 1912
Mounting for, and Relay Box	1374	June, 1917
Pinnacle and Cable Outlet	1181	June, 1917
Channel Pins	1086	Oct., 1912
Compensation Chart	1102	Oct., 1919
Compensator, Pipe—		
Horizontal, one-way	1014	March, 1919
Vertical, one-way	1231	March, 1919
Conduit—		
Cable Hanger Sockets, Sewer Steps and Manhole Clevis	1334	Sept., 1914
Duct Reducers, Mandrels, Duct Plugs and Dowel Pins	1332	Sept., 1914
Duct, Vitrified Clay	1335	Oct., 1913
Method of Laying		
Single and Multiple Duct	1336	Oct., 1913
Single and Sewer Pipe Duct	1331	Sept., 1914
Manhole		
Brick	1338	Sept., 1914
Concrete	1337	Sept., 1914
Manhole, Frame and Cover (10")	1333	Sept., 1914
Manhole, Frame and Cover (4")	1339	Sept., 1914
Cranks—		
Adjusting	1199	Sept., 1914
Adjusting and Assembly	1361	May, 1915
Forged, Details	1007	Nov., 1913
Pipe Compensator	1013	Nov., 1913
Crank Stands—		
Horizontal, Assembly with two and three arms	1057	Feb., 1914
Horizontal, one-way	1008	June, 1913
Horizontal, one and two-way	1011	Nov., 1913
Horizontal, Two-way	1009	June, 1913

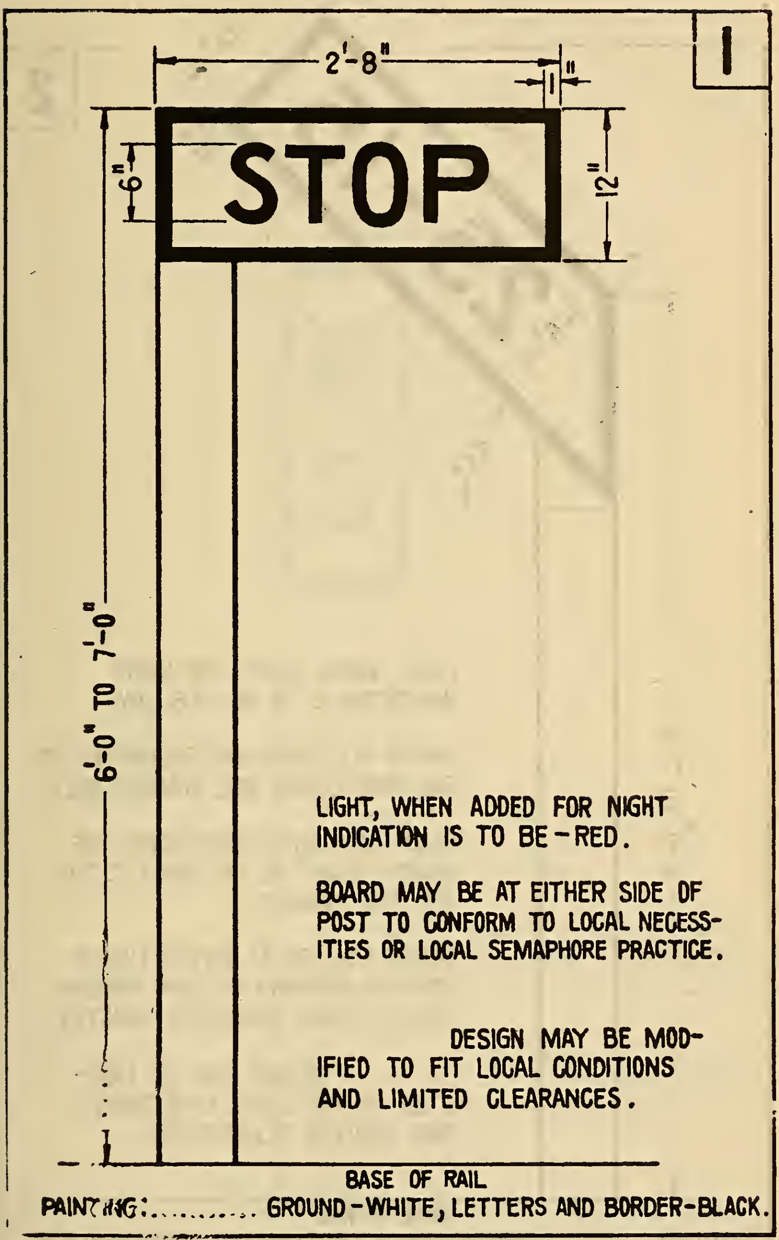
Drawing	*No.*	*Last Revision Date*
Horizontal, Two-way, Separate Pin	1393	Sept., 1916
Vertical		
Multiple	1067	Nov., 1913
Single	1066	Nov., 1913
Cross-arms	1089	Oct., 1912
Cross-arm—		
Bolt	1220	Oct., 1912
Brace	1219	Oct., 1912
Pin, Cap Gage	1167	March, 1912
Pin, Standard Steel	1165	Oct., 1912
Pin, Steel Terminal	1166	Oct., 1912
Deflecting Bars	1069	Oct., 1917
Deflecting Stand—		
Horizontal, Adjustable	1396	Oct., 1917
Vertical	1068	Dec., 1917
Detector Bars	1098	Oct., 1917
Position of, and Location of Clip Bolts.	1099	June, 1913
Dwarf Signals, Mechanical	1097	Sept., 1914
Bearings, Top and Base	1232	Sept., 1914
Fittings	1239	Sept., 1914
Spectacle and Lamp Bracket Support	1233	Sept., 1914
Electrical Instruments—		
Scale Ranges for	1378	March, 1917
Foundations—		
For Channel Column Bracket Post	1105	Oct., 1913
For Compensator, Concrete	1104	March, 1913
For Dwarf Signals	1106	March, 1913
For Ground Mast Bottom Mechanism Signals	1259	May, 1916
For Ground Mast Mechanical Signals, Concrete	1107	May, 1916
For Horizontal Crank and Wheel Stand, Concrete	1103	Oct., 1913
For Pipe Bracket Posts, Concrete	1108	Oct., 1913
Ladder	1052	Dec., 1913
Pipe Carrier		
Cast Iron, with Wood Top and Bottom	1109	Dec., 1909
Concrete	1080	Feb., 1914
Fuses—		
Cartridge, Enclosed	1309	Oct., 1914
Globes—		
Hand Lantern	1394	Dec., 1917
Grounds, for Lightning Arresters	1424	Nov., 1917
Hydrometer—		
Lead Type Storage Battery	1175	Sept., 1916
Indication Locking, Circuit	1173	June, 1912
Insulation—		
One-Inch Pipe Line	1094	Sept., 1916
Switch Rod	1055	Sept., 1914
Jaws—		
Screw and Solid	1016	Sept., 1916
Solid with Tang Ends	1018	Nov., 1913
Tang End and Adjustable Link	1019	Sept., 1916
Junction Box	1155	....
Ladders—		
Clamps and Stays	1371	Dec. 1918
For Bracket Mast Signals	1366	March, 1918

Drawing	*No.*	*Last Revision Date*
For Bracket Posts	1372	March, 1918
For Ground Mast Signals	1365	March, 1918
Hand Rails	1363	March, 1918
Parts	1362	Dec., 1918
Platforms	1364	March, 1918
Lamp, Electric Incandescent	1329	Sept., 1914
Lamp, Semaphore	1100	June, 1918
Bracket, Adjustable	1049	March, 1914
Case, Electric, Details and Assembly	1222	Dec., 1918
Case, Electric, Details	1395	Dec., 1918
Equipment	1101	April, 1914
Lamp, Switch	1460	Sept., 1919
Base Socket For	1461	Sept., 1919
Leadaway	1402	June, 1916
Leadouts, Tower		
Channel and I-Beams	1202	June, 1912
Cranks and Deflecting Bar,		
Foundation For	1203	June, 1912
Mounted	1204	June, 1912
Mounted (Details)	1205	June, 1912
Cranks, Deflecting Bars and Rocking Shafts		
Foundation For	1217	Oct., 1912
Deflecting Bars and Rocking Shafts		
Mounted	1206	June, 1912
Rocking Shafts		
Foundation For	1200	June, 1912
Mounted	1201	June, 1912
Mounted, Low Bearings	1201	June, 1912
Lock Rod, Adjustable	1237	May, 1914
Marker Lights	1238	March, 1914
Masts, Signal	1035	Dec., 1915
Ground		
Base For	1034	Jan., 1914
Clamp for Base	1059	Dec., 1915
Bridge and Bracket		
Base For	1036	Feb., 1914
Clamp for Base	1178	Feb., 1914
Mechanical Connections for three-arm	1191	Oct., 1912
"U" Bolts and Clamps For	1083	Feb., 1914
Pinnacle	1050	Feb., 1914
Pins—		
Crank and Jaw	1010	Sept., 1915
Pipe—		
One-inch Signal and Coupling	1015	March, 1915
Pipe Carrier—		
Details and Assembly	1085	June, 1913
Side	1084	Oct., 1913
Strap	1071	Dec., 1913
Tranverse, Assembly	1072	Dec., 1913
Tranverse, Details of	1073	March, 1916
Pipe Run, Turn In	1400	June, 1916
Plunger Lock	1096	Aug., 1914
Pneumatic Interlocking—		
Graphical Representation of Air Supply For	1389	May, 1915

Drawing	*No.*	*Last Revision Date*
Power Interlocking—		
Graphical Representation of Electrical Energy Supply For	1388	Sept., 1915
Rectifier—		
Mercury Arc, Panel	1242	June, 1913
Relay Box—		
Assembly on Cable Post	1185	June, 1917
Sizes "A" and "B"	1182	June, 1917
Detail, Size "A"	1184	Oct., 1917
Detail, Size "B"	1183	Oct., 1917
Fittings and Terminal Boards	1369	Oct., 1917
Inlet Bracket	1367	June, 1917
Linings and Terminal Boards	1368	June, 1917
Mountings for, and Cable Post	1374	June, 1917
Resistance, Adjustable	1422	June, 1918
Rocking Shaft—		
Arms	1060	Oct., 1912
Assembly and Details	1062	Dec., 1912
Bearings	1061	Dec., 1912
Bearings, Low	1063	Oct., 1913
Screws—		
1. Wire Adjusting	1001	Oct., 1913
2. Pipe Adjusting	1002	Feb., 1914
Semaphore—		
Spectacle		
Clearance	1093	Dec., 1913
Design "A"	1040	May, 1913
Design "B"	1041	May, 1913
Design "C"	1235	March, 1916
Filler Block for 0° to 45° Travel	1090	Dec., 1913
Filler Block for 45° to 90° Travel	1091	Dec., 1913
Filler Block for Fixed Arms	1092	Dec., 1913
Torque Curve for Electric	1064	Dec., 1912
Bearing, Mechanical	1082	Sept., 1916
Details and Assembly	1194	March, 1917
Signals—		
Adapter Base for Ground Mast Bottom Mechanism	1387	Sept., 1916
Guide Clamps for Vertical Connections	1021	June, 1917
Guide for Vertical Connections	1023	March, 1915
Guide Supports and Caps for Vertical Connections	1022	March, 1915
Signals—		
Mechanical		
Crank Bearings and Clamps For	1355	March, 1916
Crank Bearings and Clamps for (6" Pine)	1398	June, 1918
Double Spectacle Bearing and Lamp Bracket For	1356	March, 1916
Ladder For	1357	March, 1916
Operating Connection For	1195	March, 1917
One Arm, Ground	1043	Sept., 1915
Two Arm, Ground	1044	Sept., 1915
Three Arm, Ground	1045	Sept., 1915
Two Way, Single, Lamp	1236	March, 1916
Stuffing Box—		
For One-Inch Pipe	1225	March, 1913
For Wire	1226	March, 1916

Drawing	*No.*	*Last Revision Date*
Switch Boards—		
Charging Panels, Electric Interlocking.	1244	June, 1913
Charging Panels, Electric Interlocking, Circuits For	1246	June, 1913
Charging Panels, Line, Circuits For...	1420	Sept., 1916
Charging Panels, Line	1174	Sept., 1916
Charging Panels, Electric Interlocking, Manipulation Chart For	1247	June, 1913
Generator Charging Panel	1379	Sept., 1916
Knife Switches and Clips	1344	March, 1914
Mercury Arc Rectifier Panel	1242	June, 1913
Motor Panel	1240	March, 1913
Single Throw Switches	1345	March, 1914
Supports	1243	Oct., 1913
Switch Box Connections	1223	Aug., 1914
Switches—		
Single Throw	1345	March, 1914
Tang Ends—		
Double	1376	March, 1918
Lug and Compensator Link	1017	Sept., 1916
With Screw Jaws	1360	Dec., 1915
Target Stand, Low	1399	March, 1916
Terminal Block	1056	Oct., 1916
Terminal Box and Bootleg	1154	Dec., 1911
Thermometer—		
For Lead Type Storage Battery	1375	Nov., 1917
Trunking—		
Bootleg Terminal	1157	Dec., 1911
Built-Up	1177	May, 1912
Grooved	1176	May, 1912
Junction Box	1155	....
Terminal Box and Bootleg	1154	Dec., 1911
To be used where wires are placed under ground in petroleum asphaltum	1156	Dec., 1911
Wall Machine, two lever	1197	Dec., 1915
Wall Machine, two lever, details	1397	Dec., 1915
Wheels, Chain—		
Horizontal	1350	Oct., 1913
Vertical		
High	1352	Oct., 1913
Low	1351	Oct., 1913

[11]SIGNALS FOR TRAIN OPERATION.



LIGHT, WHEN ADDED FOR NIGHT INDICATION IS TO BE—RED.

BOARD MAY BE AT EITHER SIDE OF POST TO CONFORM TO LOCAL NECESSITIES OR LOCAL SEMAPHORE PRACTICE.

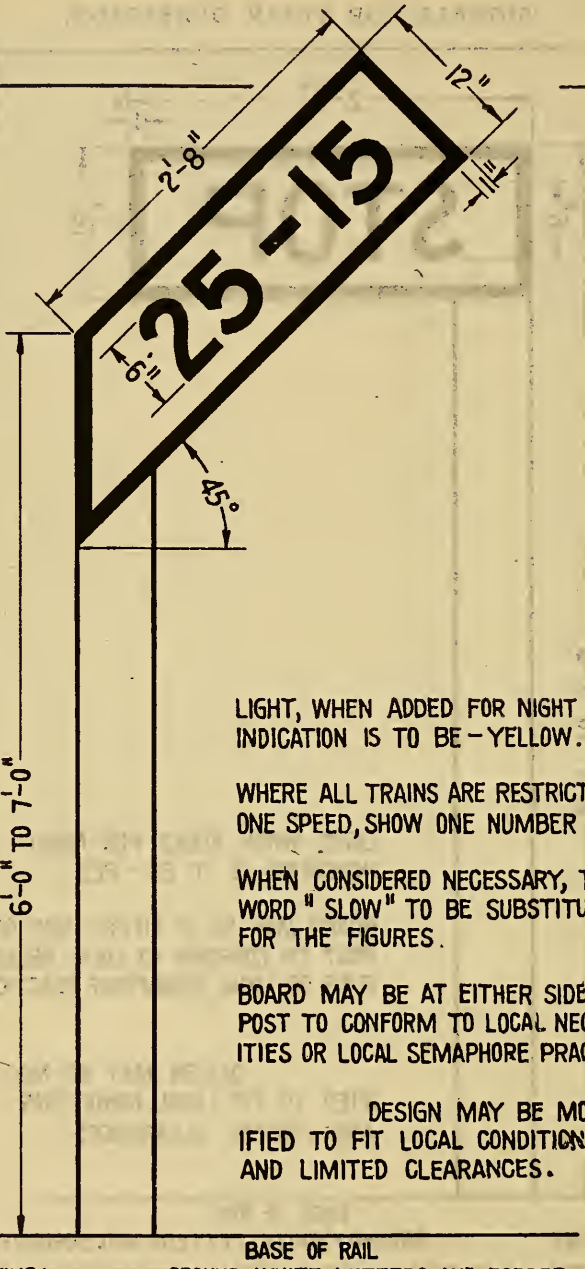
DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:............ GROUND-WHITE, LETTERS AND BORDER-BLACK.

---

[11] Adopted, Vol. 19, 1918, pp. 78-88, 1086.

2



LIGHT, WHEN ADDED FOR NIGHT INDICATION IS TO BE – YELLOW.

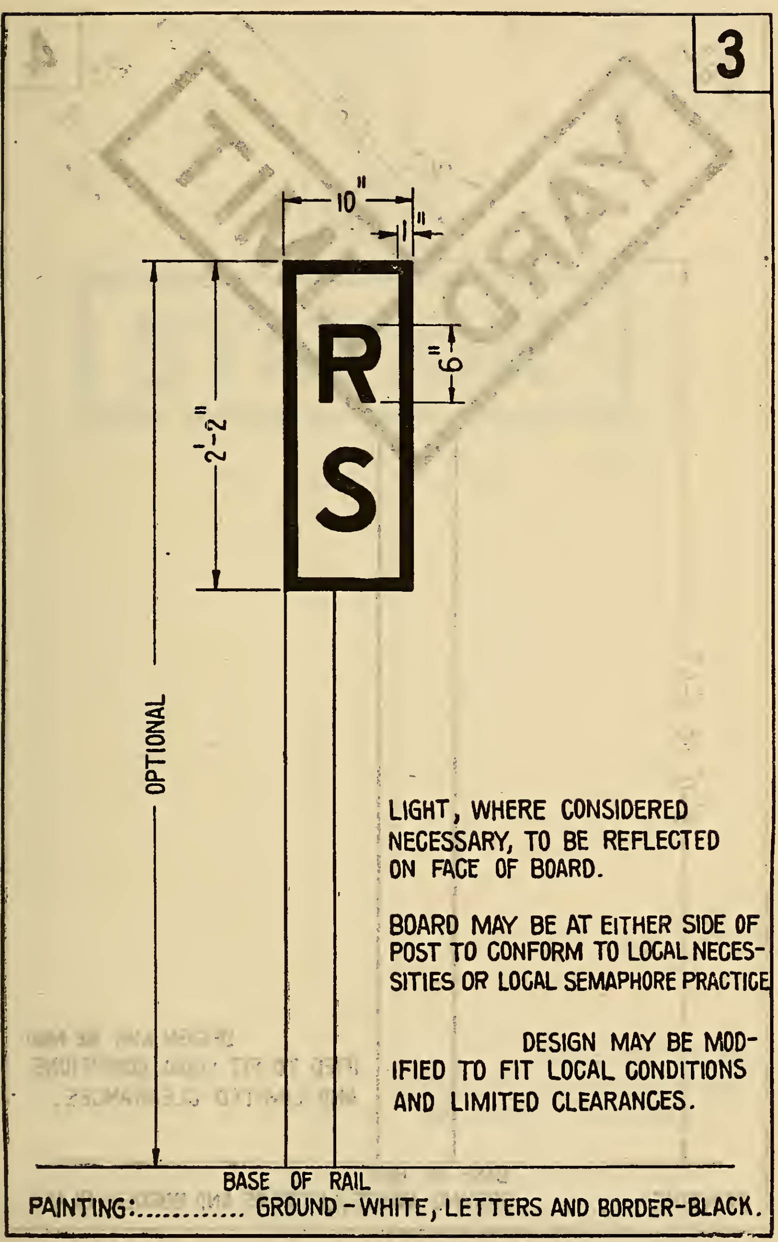
WHERE ALL TRAINS ARE RESTRICTED TO ONE SPEED, SHOW ONE NUMBER ONLY.

WHEN CONSIDERED NECESSARY, THE WORD " SLOW" TO BE SUBSTITUTED FOR THE FIGURES.

BOARD MAY BE AT EITHER SIDE OF POST TO CONFORM TO LOCAL NECESSITIES OR LOCAL SEMAPHORE PRACTICE.

DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:........... GROUND–WHITE, LETTERS AND BORDER–BLACK.

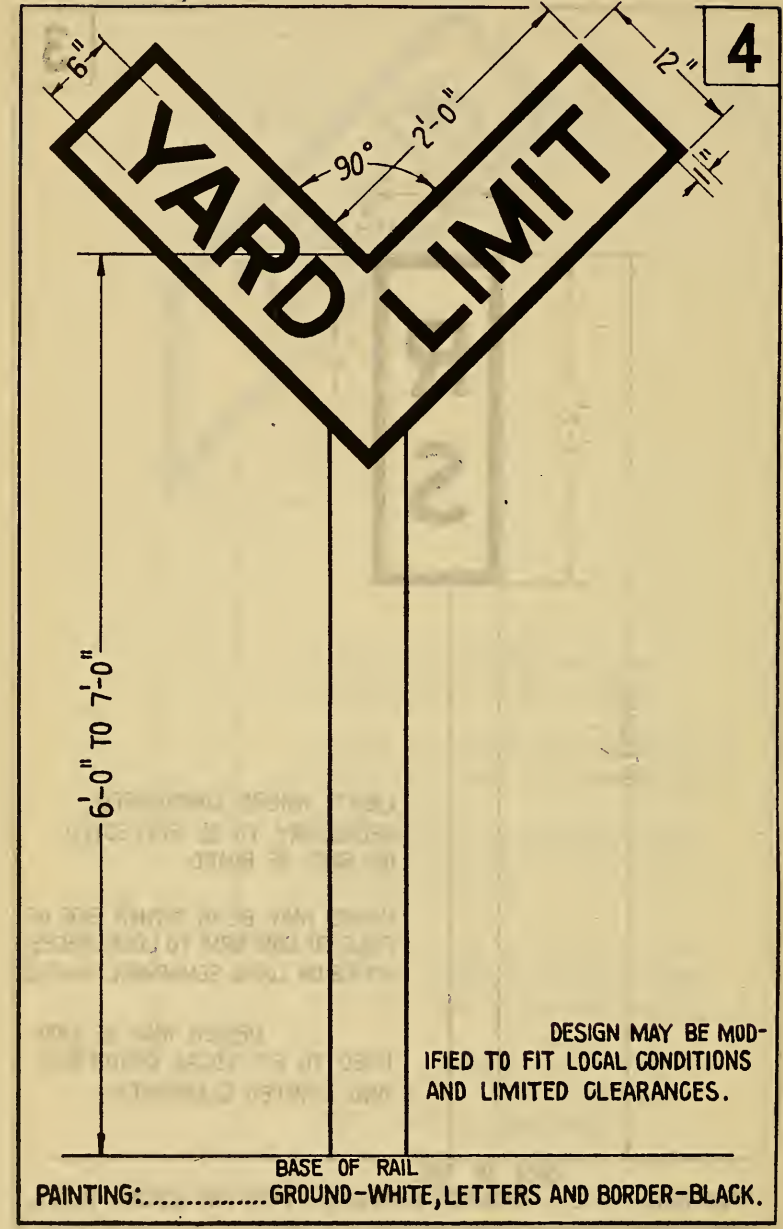


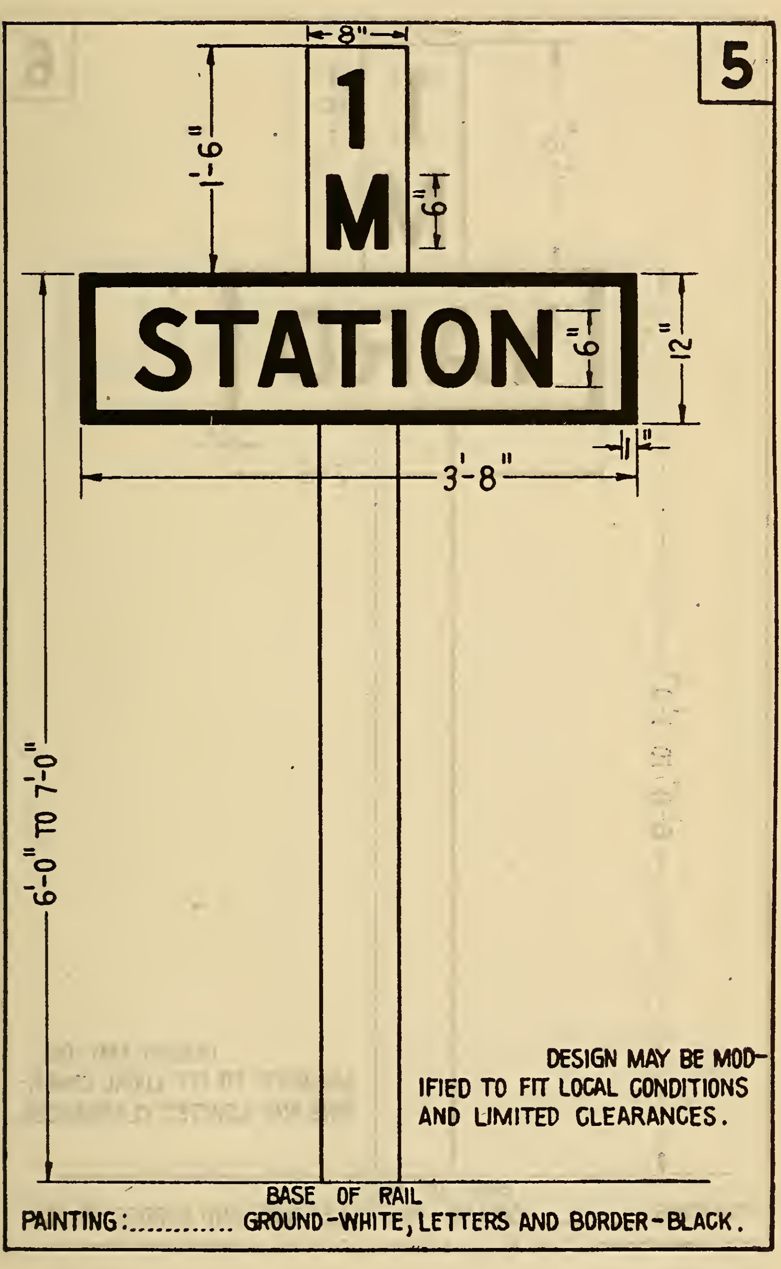
LIGHT, WHERE CONSIDERED NECESSARY, TO BE REFLECTED ON FACE OF BOARD.

BOARD MAY BE AT EITHER SIDE OF POST TO CONFORM TO LOCAL NECESSITIES OR LOCAL SEMAPHORE PRACTICE

DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

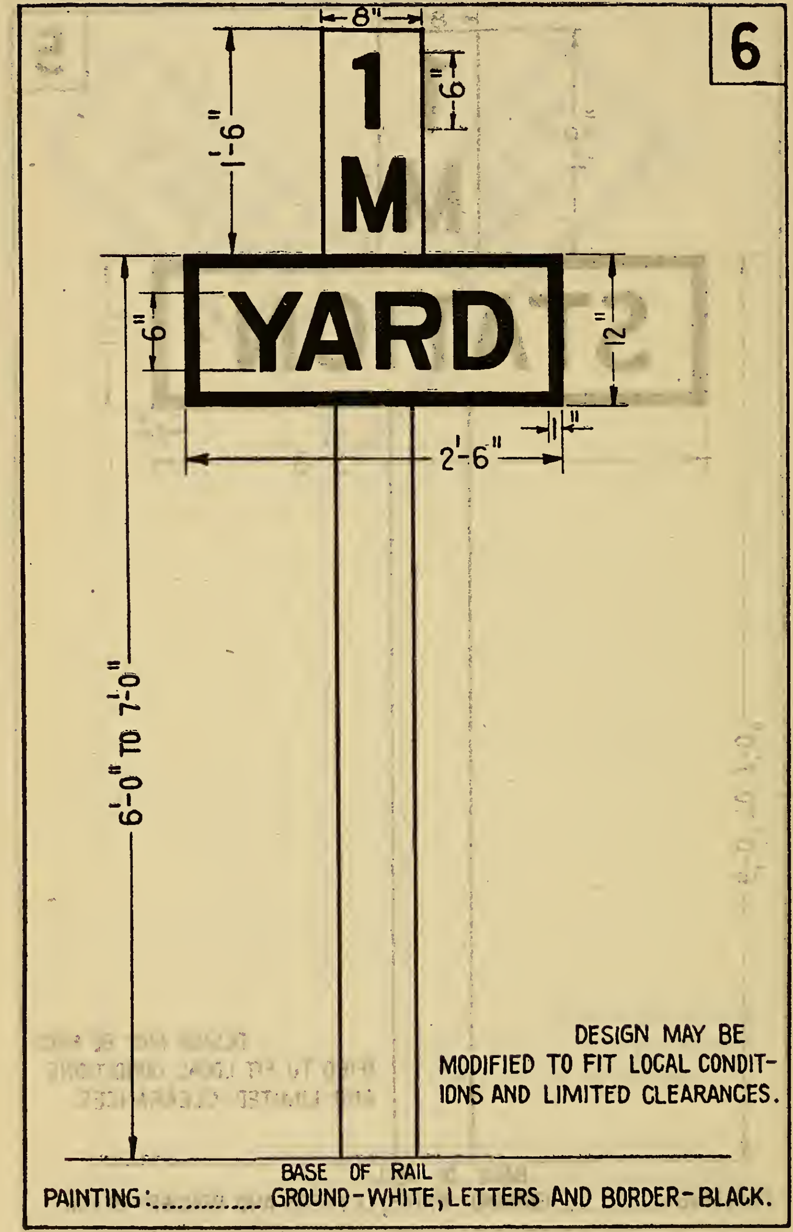
PAINTING:............ GROUND - WHITE, LETTERS AND BORDER-BLACK.


4
6"
2'-0"
12"
90°
1"
YARD
LIMIT
6'-0" TO 7'-0"
DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.
BASE OF RAIL
PAINTING:...............GROUND-WHITE, LETTERS AND BORDER-BLACK.



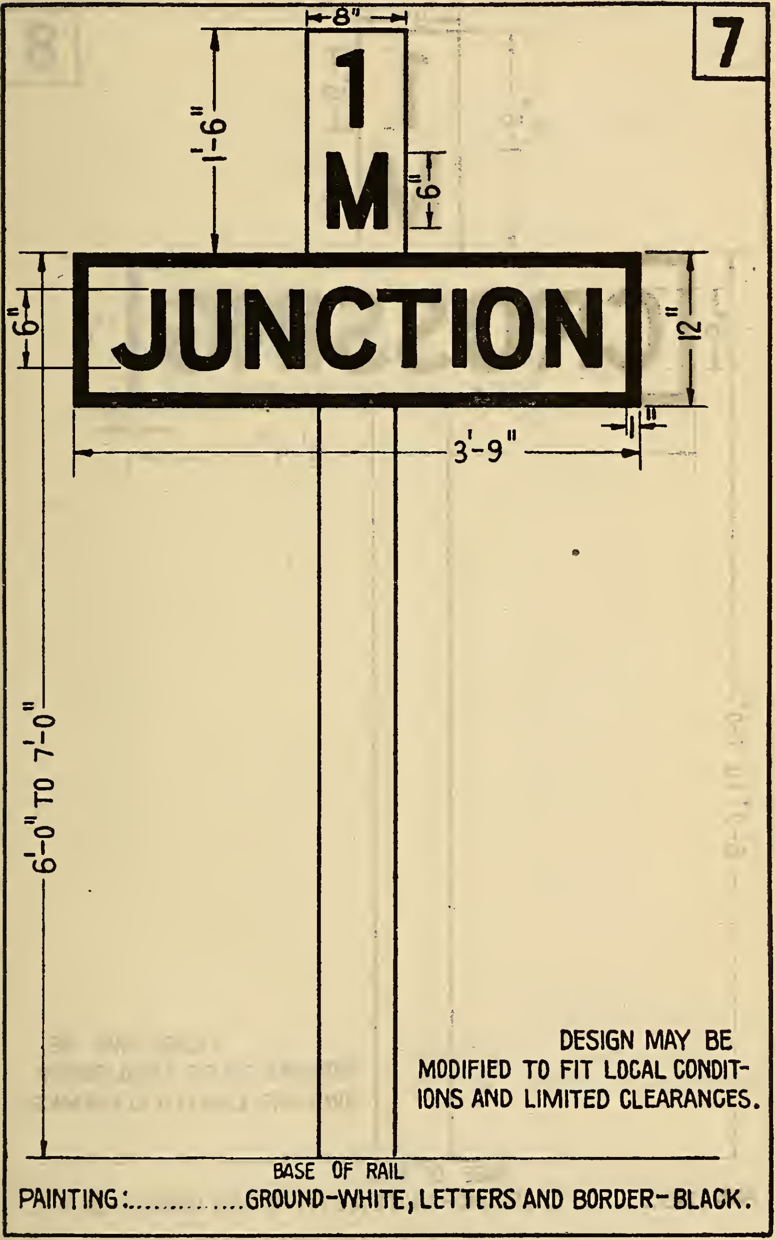
DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:............ GROUND-WHITE, LETTERS AND BORDER-BLACK.



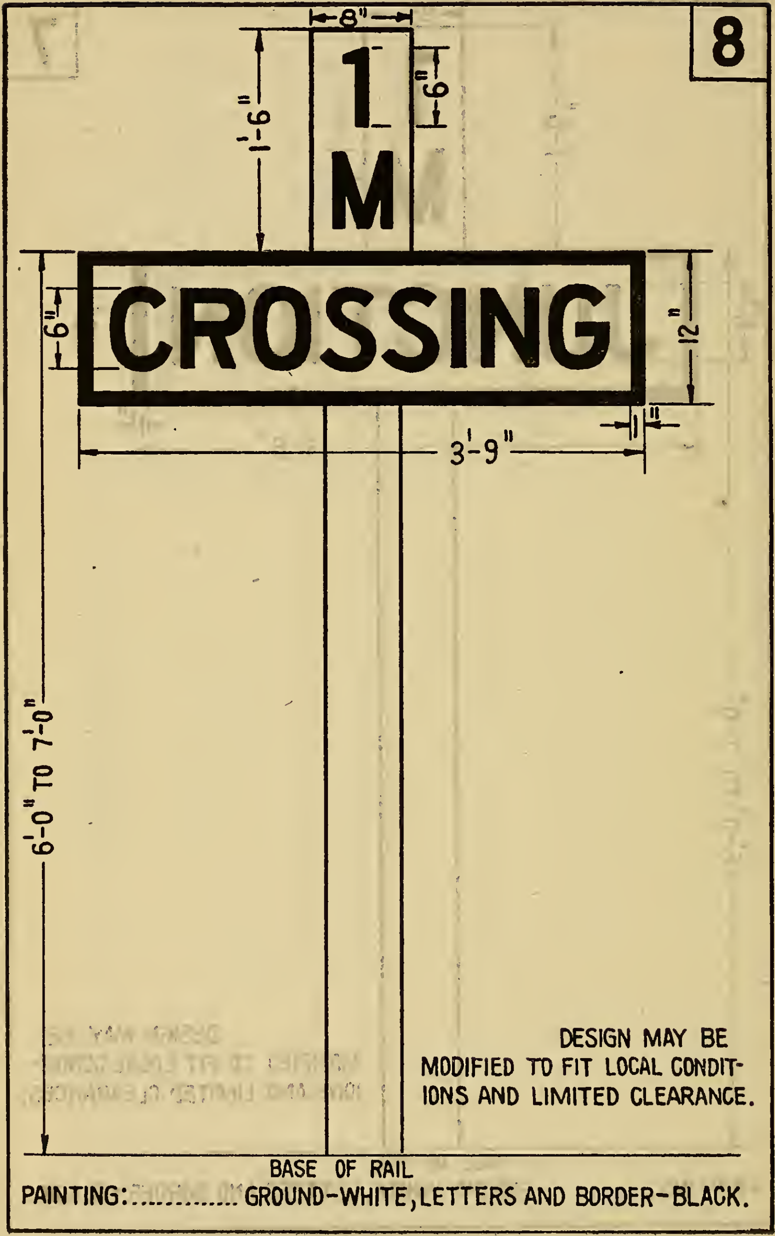
DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

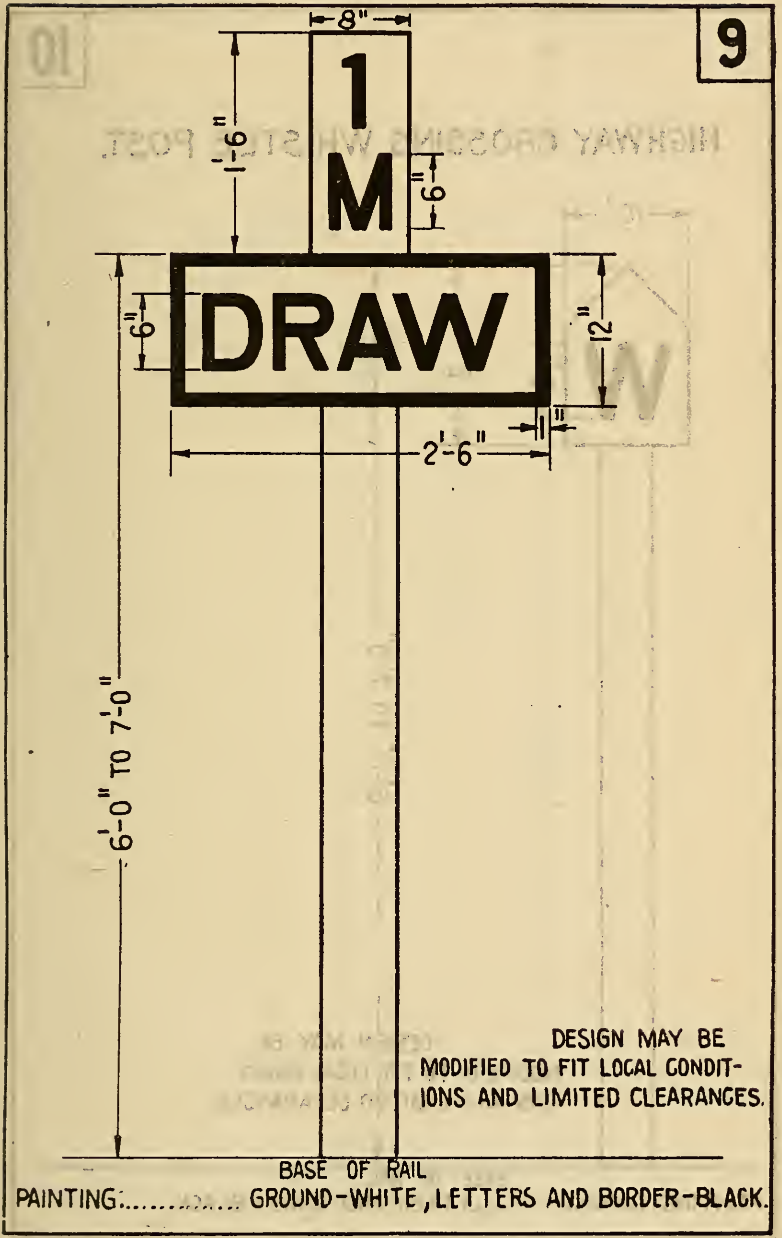
PAINTING:............. GROUND-WHITE, LETTERS AND BORDER-BLACK.



DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:..............GROUND-WHITE, LETTERS AND BORDER-BLACK.


8
8"
1'-6"
6"
1
M
CROSSING
6"
12"
1"
3'-9"
6'-0" TO 7'-0"
DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCE.
BASE OF RAIL
PAINTING:............GROUND-WHITE, LETTERS AND BORDER-BLACK.

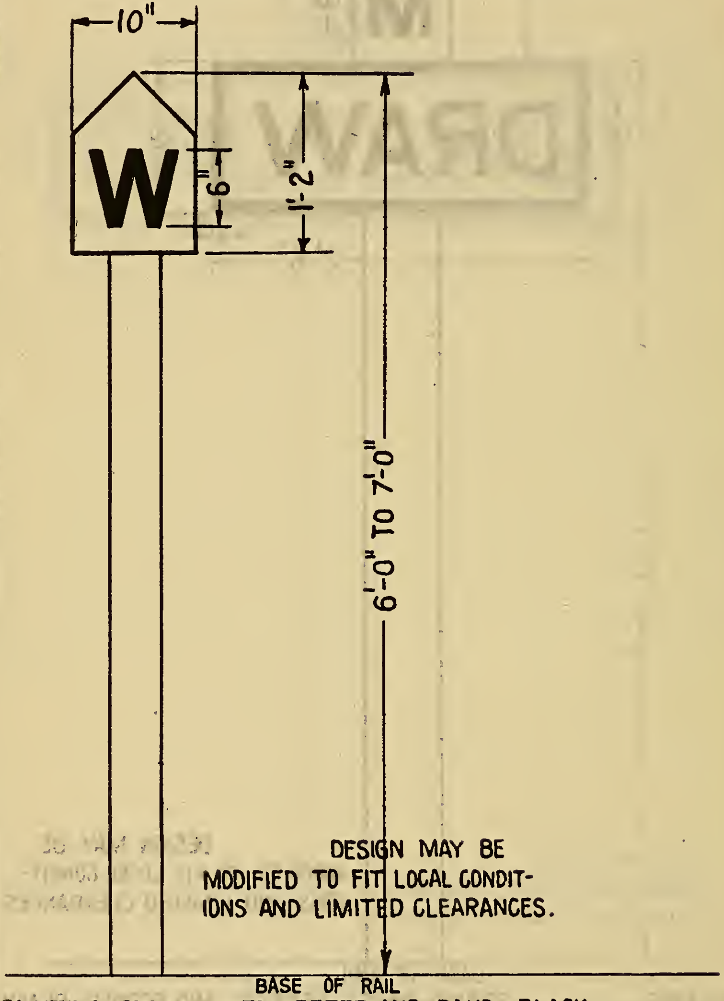


DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:............ GROUND-WHITE, LETTERS AND BORDER-BLACK.

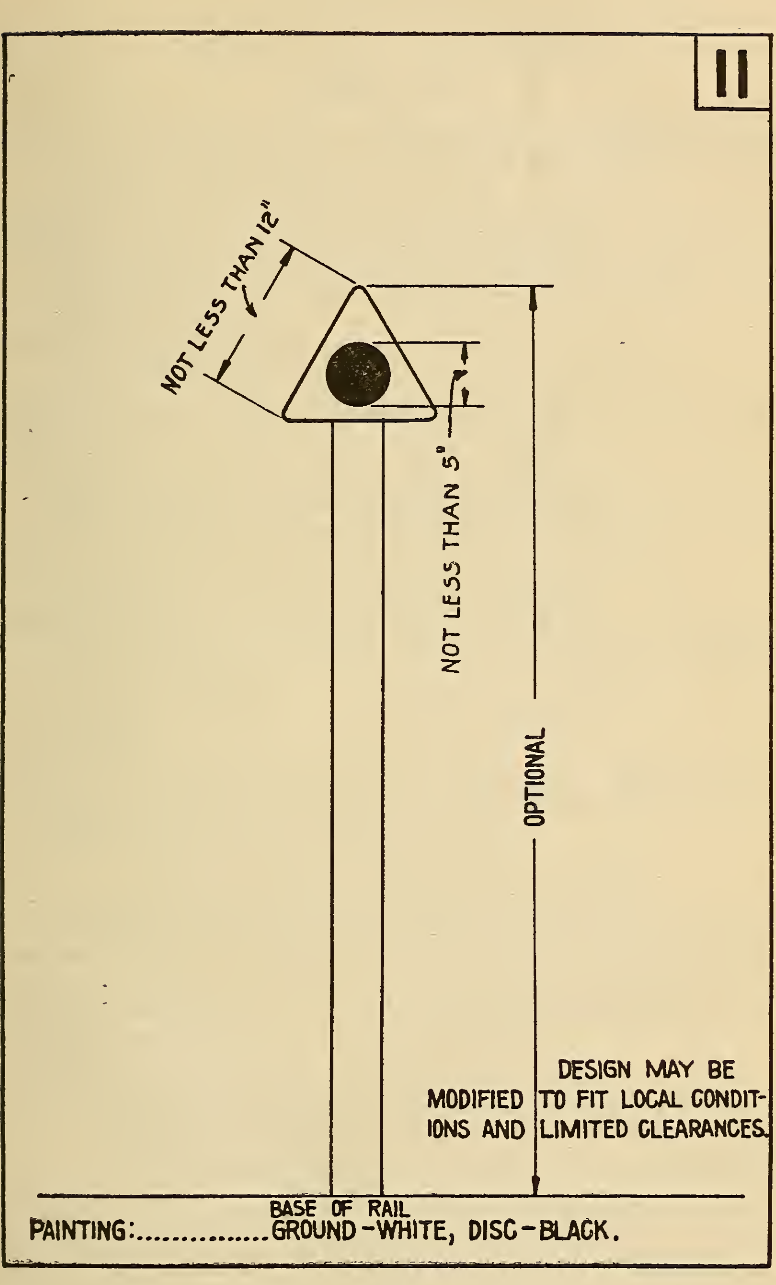
10

HIGHWAY CROSSING WHISTLE POST.



DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING: GROUND WHITE, LETTER AND BAND - BLACK.



DESIGN MAY BE MODIFIED TO FIT LOCAL CONDITIONS AND LIMITED CLEARANCES.

PAINTING:................GROUND-WHITE, DISC-BLACK.

COMMITTEE XI.

RECORDS AND ACCOUNTS.

[1] DEFINITIONS.

Account.—A statement required to enable payment to be made for labor performed, material furnished, or to establish the detail and total cost of work or class of expenses.

Conventional Sign.—A symbol, such as a mark, character, abbreviation or letter, selected or sanctioned by general agreement or common use to indicate upon a map or plan certain forms, conditions or objects, both natural and structural.

Ledger Account.—An account of an individual piece of work or class of expense kept in ledger form.

Progress Profile.—A graphical record showing status of work at stated periods.

Record.—Authenticated information or data in graphical, tabular or statement form relating to physical characteristics, conditions, cost and such other information as may seem desirable for preservation.

Report.—The medium through which information is transmitted and from which records and accounts are prepared or compiled.

Right-of-Way Map.—A plat representing the actual location and dimensions of the property, franchises or other rights owned or controlled by a railway company.

Track Chart.—A diagram showing the physical characteristics of roadway and track.

Track Map.—A plat showing existing physical plant, including tracks, bridges, buildings, water service and mains, leases, station facilities and all other physical and operating property.

[2] ENGINEERING DEPARTMENT FORMS.

A properly organized and equipped Railway Engineering Department must have at hand correct information of the progress of work under construction, and the location, extent and condition of the operated property. As means for keeping up this record the following forms are considered essential and recommended:

A. Construction Reports and Records.

General Contract Form...	(See Form of Construction Contract)
Steam Shovel Reports..........	(See page 49 for description)
Daily Track Laying Report........................	Form 1100
Daily Ballasting Report..........................	Form 1101

---

[1] Adopted, Vol. 7, 1906, pp. 279, 318; Vol. 9, 1908, pp. 663, 664, 667, 668, 677, 686; Vol. 18, 1907, pp. 752, 1525; Vol. 22, 1921, pp. 904, 1083.

[2] Adopted, Vol. 5, 1904, pp. 237, 372-375; Vol. 6, 1905, pp. 656, 657, 668; Vol. 11, 1910, pp. 1100, 1103, 1141; Vol. 15, 1914, pp. 924, 1157; Vol. 16, 1915, pp. 786, 1085; Vol. 21, 1920, pp. 368, 1456.

Monthly and Final Estimates of Contract Work:

- (a) Grading ....Form 1102
- (b) Other Road Accounts.....................Form 1103
- (c) Buildings ....Form 1104
- (d) Summary ....Form 1105

B. Maintenance Reports and Records.

1. Track:

- (a) Side Track Record.......................Form 1106
- (b) Monthly Track Material Report..........Form 1107
- (c) Report of Rail Failures in Main Track.... (See Form 402-A)
- (d) Foreman's Monthly Tie Removal Report... (See Form 300)

2. Bridges and Buildings:

- (a) Monthly Bridge Material Report..........Form 1108
- (b) Bridge Section Tool Report..............Form 1109
- (c) Bridge Inspection Report.................Form 1110
- (d) Current Bridge Inspection Report........Form 1111
- (e) Pile Record Form..................(See Form 701)

3. Water Service:

- (a) Geological Record of Well........(See Form 1304)
- (b) Water Station Record..............(See Form 1303)
- (c) Pumper's Daily Report............(See Form 1301)
- (d) Cost Record of Pumping Water....(See Form 1302)

4. Signals and Interlockers:

Form for Recording Signal Performance...... (See Forms of R. S. A.)

- (a) Conductor's or Engineman's Telegraphic Report ....(See Form R. S. A. 11)
- (b) Dispatcher's Telegraphic Report.......... (See Form R. S. A. 12)
- (c) Signal Maintainer's Report..(See Form R. S. A. 21)
- (d) Signal Inspector's or Maintainer's Report (See Form R. S. A. 22)
- (e) Signal Engineer's or Supervisor's Report .... (See Form R. S. A. 3)

5. Appraisals, Valuation Records and Accounting:

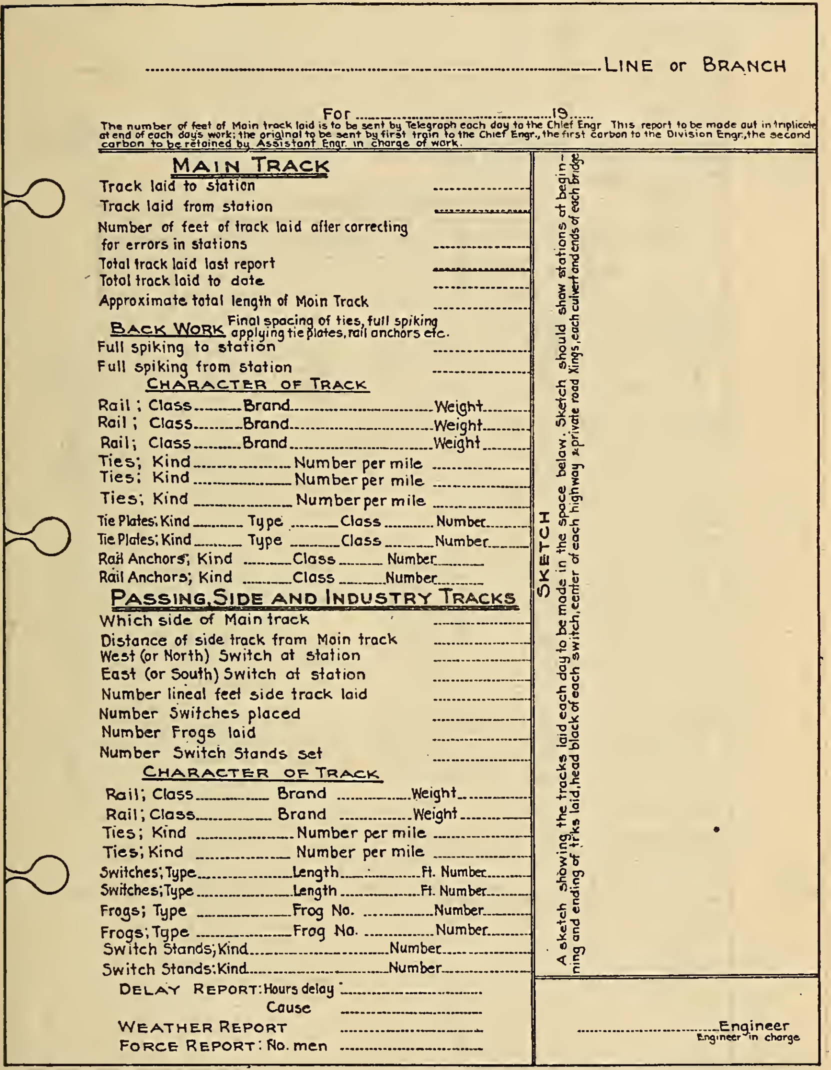
- (a) Authority for Expenditure...............Form 1113
- (b) Detailed Estimate ....Form 1114
- (c) Register of Authorities for Expenditure..Form 1115
- (d) Monthly Report of Expenditures........Form 1116
- (e) Roadway Completion Report....Form 1117 to 1117C
- (f) Equipment Completion Report............Form 1118

6. Labor and General Forms:

- (a) Time Roll...............................Form 1119
- (b) Contract and Lease Record..............Form 1120
- (c) Register of Title Deeds..(See D. V. Forms 107-8—I. C. C.)

DAILY TRACK LAYING REPORT AND RECORD.

Form 1100



.... LINE or BRANCH

For .... 19.....

The number of feet of Main track laid is to be sent by Telegraph each day to the Chief Engr. This report to be made out in triplicate at end of each day's work; the original to be sent by first train to the Chief Engr., the first carbon to the Division Engr., the second carbon to be retained by Assistant Engr. in charge of work.

MAIN TRACK

Track laid to station ....
Track laid from station ....
Number of feet of track laid after correcting for errors in stations ....
Total track laid last report ....
Total track laid to date ....
Approximate total length of Main Track ....

BACK WORK Final spacing of ties, full spiking applying tie plates, rail anchors etc.

Full spiking to station ....
Full spiking from station ....

CHARACTER OF TRACK

Rail; Class .... Brand .... Weight ....
Rail; Class .... Brand .... Weight ....
Rail; Class .... Brand .... Weight ....
Ties; Kind .... Number per mile ....
Ties; Kind .... Number per mile ....
Ties; Kind .... Number per mile ....
Tie Plates; Kind .... Type .... Class .... Number ....
Tie Plates; Kind .... Type .... Class .... Number ....
Rail Anchors; Kind .... Class .... Number ....
Rail Anchors; Kind .... Class .... Number ....

PASSING, SIDE AND INDUSTRY TRACKS

Which side of Main track ....
Distance of side track from Main track ....
West (or North) Switch at station ....
East (or South) Switch at station ....
Number lineal feet side track laid ....
Number Switches placed ....
Number Frogs laid ....
Number Switch Stands set ....

CHARACTER OF TRACK

Rail; Class .... Brand .... Weight ....
Rail; Class .... Brand .... Weight ....
Ties; Kind .... Number per mile ....
Ties; Kind .... Number per mile ....
Switches; Type .... Length .... Ft. Number ....
Switches; Type .... Length .... Ft. Number ....
Frogs; Type .... Frog No. .... Number ....
Frogs; Type .... Frog No. .... Number ....
Switch Stands; Kind .... Number ....
Switch Stands; Kind .... Number ....

DELAY REPORT: Hours delay ....
Cause ....
WEATHER REPORT ....
FORCE REPORT: No. men ....

SKETCH

A sketch showing the tracks laid each day to be made in the space below. Sketch should show stations at beginning and ending of trks laid, head block of each switch, center of each highway & private road Xings, each culvert and ends of each bridge

.... Engineer
Engineer in charge

SPECIFICATIONS FOR FORM 1100.

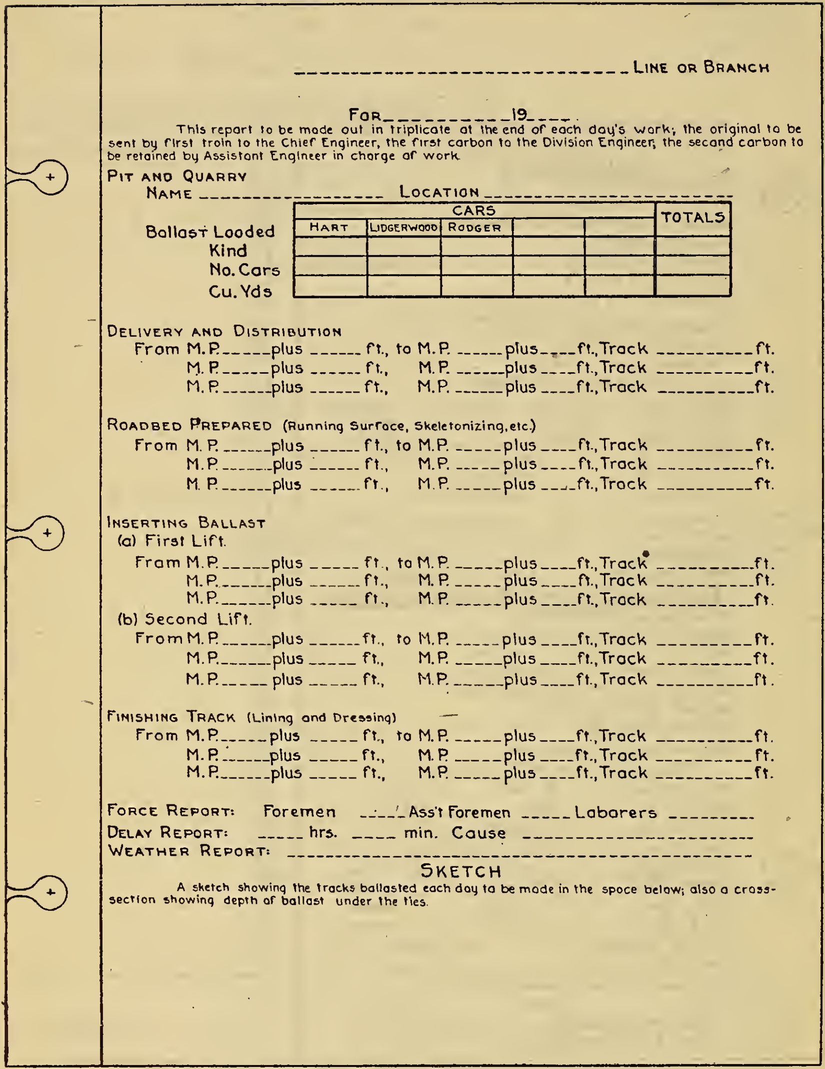
Form as shown. Size 8½x11 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

INSTRUCTIONS FOR USE OF FORM 1100.

Instructions for the use of the form are given under the title of the form.

DAILY BALLASTING REPORT AND RECORD.

Form 1101



________________________________ LINE OR BRANCH

FOR___________19____.

This report to be made out in triplicate at the end of each day's work; the original to be sent by first train to the Chief Engineer, the first carbon to the Division Engineer, the second carbon to be retained by Assistant Engineer in charge of work.

PIT AND QUARRY

NAME ____________________ LOCATION _________________________

	CARS					TOTALS
Ballast Loaded	HART	LIDGERWOOD	RODGER			
Kind						
No. Cars						
Cu. Yds						

DELIVERY AND DISTRIBUTION

From M. P._____plus ______ ft., to M. P. ______plus____ft., Track ___________ft.
M. P._____plus ______ ft., M. P. ______plus____ft., Track ___________ft.
M. P._____plus ______ ft., M. P. ______plus____ft., Track ___________ft.

ROADBED PREPARED (Running Surface, Skeletonizing, etc.)

From M. P._____plus ______ ft., to M. P. _____plus____ft., Track ___________ft.
M. P._____plus ______ ft., M. P. _____plus____ft., Track ___________ft.
M. P._____plus ______ ft., M. P. _____plus____ft., Track ___________ft.

INSERTING BALLAST

(a) First Lift.

From M. P._____plus _____ ft., to M. P. _____plus____ft., Track ___________ft.
M. P._____plus ______ ft., M. P. _____plus____ft., Track ___________ft.
M. P._____plus _____ ft., M. P. _____plus____ft., Track ___________ft.

(b) Second Lift.

From M. P._____plus ______ ft., to M. P. _____plus____ft., Track __________ft.
M. P._____plus _____ ft., M. P. _____plus____ft., Track __________ft.
M. P._____ plus _____ ft., M. P. _____plus____ft., Track ___________ft.

FINISHING TRACK (Lining and Dressing)

From M. P._____plus _____ ft., to M. P. _____plus____ft., Track ___________ft.
M. P._____plus _____ ft., M. P. _____plus____ft., Track ___________ft.
M. P._____plus _____ ft., M. P. _____plus____ft., Track ___________ft.

FORCE REPORT: Foremen _____ Ass't Foremen _____ Laborers _________
DELAY REPORT: _____ hrs. ____ min. Cause _________________________
WEATHER REPORT: ____

SKETCH

A sketch showing the tracks ballasted each day to be made in the space below; also a cross-section showing depth of ballast under the ties.

SPECIFICATIONS FOR FORM 1101.

Form as shown. Size 8½x11 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

INSTRUCTIONS FOR USE OF FORM 1101.

Instructions for the use of this form are given under the title of the form.

RESIDENT ENGINEER'S MONTHLY ESTIMATE OF GRADING.

Form 1102

________________________________ Railway

________________________ Division Branch Line   Residency No.__________

Estimate No.______________ Of Work Done, From__________________To__________________Inclusive.

For the month of______________________________, by______________________________Contractors

Note: Each Resident Engineer will make out this estimate in triplicate at the end of each month, forwarding the original and first carbon to Assistant Engineer, who will consolidate all for his line onto one form, and then forward one copy of each Resident Engineer's estimate and the consolidated estimate with Form______to Division Engineer.

LOCATION			SUB-CONTRACTOR	CLEARING AND GRUBBING						EXCAVATION								
Section	Station			Clearing. - Acres			Grubbing - Sta. of 100 Ft.			Earth - Cubic Yards			Loose Rock - Cubic Yards			Solid Rock - Cubic Yards		
	From	To		Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date
			Totals															
LOCATION			SUB-CONTRACTOR							EXTRA HAUL								
Section	Station									Over Haul - Cu. Yds. per 100 Ft.			Train Haul - Cu. Yds. per Mile					
	From	To		Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date
			Totals															

Note: Blank columns to be used for other items.
Note: The data from which this estimate was made was taken from Field Note Book No.______Pages_____

I hereby Certify that the above Estimate is Correct______________________Resident Engineer.

Examined and Approved______________________Assistant Engineer.

RESIDENT ENGINEER'S MONTHLY ESTIMATE OF BRIDGES AND OTHER ROADWAY ITEMS.

Form 1103

_________________________________RAILWAY.
_________________________________DIVISION; BRANCH; LINE; RESIDENCY No.__________

ESTIMATE No.__________ OF WORK DONE, FROM __________ TO __________ INCLUSIVE.

For the month of ________________, by ______________________ Contractors

Note:- Each Resident Engineer will make out this estimate in triplicate at the end of each month, Forwarding the original and first Carbon to Assistant Engineer who will consolidate all for his line onto one form and then forward one copy of each Res Engrs estimate and the consolidated estimate with form __________ to Division Engr. Use this form for Bridges, Culverts, Track laying, Ballasting, Fencing, Automatic block signals Etc

LOCATION			SUB-CONTRACTOR															
Section	Station																	
	From	To		Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date
			Total															

LOCATION			SUB-CONTRACTOR															
Section	Station																	
	From	To		Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date	Present Estimate	Previous Estimate	Total Work To Date
			Total.															

Note:- The data from which this estimate was made was taken from Field Book No.__________ Pages__________

I hereby Certify that the above Estimate is correct________________Res. Engr.

Examined and Approved________________Ass't. Engr.

RESIDENT ENGINEER'S MONTHLY ESTIMATE OF BUILDINGS.

Form 1104

FORM........

_______________________________RAILWAY

_________________________ DIVISION
BRANCH
LINE

ESTIMATE No.______________ OF WORK FOR THE MONTH OF ______________________ 19___

BY ______________________________ CONTRACTOR, Under Contract dated __________________

NOTE:- This form to be used for monthly estimate of work constructing Station Buildings, Fuel Stations, Water Stations, Shop Buildings, Engine Houses, Roadway Buildings and all other buildings.

NAME OF BUILDING OR OTHER STRUCTURE	LOCATION	CONTRACT PRICE	PRESENT ESTIMATE		PREVIOUS ESTIMATES		TOTAL WORK TO DATE	
			QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
				$		$		$
			Total	$		$		$
			___% Retained					
			Balance					

I hereby certify that the above Estimate is correct. ______________________ Resident Engineer

Examined and Approved. ______________________ Assistant Engineer

ASSISTANT ENGINEER'S CONSOLIDATED MONTHLY ESTIMATE.

Form 1105

FORM........

-- RAILWAY

------------------------------ DIVISION BRANCH LINE

ESTIMATE Nº .... OF WORK FOR THE MONTH OF .... 19....

BY .... CONTRACTOR, Under Contract dated ....

NOTE :- This form will be made out by the Assistant Engineer as a consolidation from Forms .... for all work done under contract under his direction. Blank lines should be used for Classes of work or items not shown.

CLASSIFICATION	UNITS	UNIT CONTRACT PRICE	PRESENT ESTIMATE		PREVIOUS ESTIMATES		TOTAL WORK TO DATE		DISTI BUTIO
			QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT	
Clearing	Acre			$		$		$	
Grubbing	Sq. Rod								
Unclassified Excavation, Haul not to exceed .... Ft	Cu Yds.								
Earth Excavation, Haul not to exceed .... Feet	"								
Earth Excavation, " from .... to 1000 Feet	" "								
Hard Pan ", " not to exceed 1000 Feet	" "								
Loose Rock ", " " " " 1000 Feet	"								
Shell Rock ", " " " " 1000 Feet	"								
Solid Rock ", " " " " 1000 Feet	" "								
Embankment. Haul not to exceed .... Feet	" "								
Embankment. Haul from .... to 1000 Feet	"								
Solid Rock Borrow, Haul not to exceed 100 Feet	" "								
RipRap, Loose, Haul not to exceed 1000 Feet	" "								
RipRap, Hand Placed, " " " " 1000 Feet	" "								
Extra Haul	Cu.Yds.100F								
Train Haul	Cu.Yds-Mi.								
Piling Driven	Lin. Ft.								
Piling Cut Off	" "								
Timber in Structures	M.F.B.M.								
Cast Iron in Structures	Pound								
Wrought Iron in Structures	"								
Track Laying, Main Track	Mile								
Track Laying, Side and other Tracks									
Switches placed	Each								
Placing Tie Plates, Track fully tie-plated.	Mile								
Placing Tie Plates, Track not fully tie-plated	Each								
Ballasting	Cu.Yd.								

Extra Work, per Force Account*									Distributio shown on Bil
			Total	$		$		$	
			% Retained						
			Balance						

*Attach to this Estimate a tabulated statement listing each Extra Bill and showing the distribution

I hereby certify that the above Estimate is correct. .... Assistant Engineer.

MONTHLY AND FINAL ESTIMATES OF CONTRACT WORK:

(a) *Grading* Form 1102

SPECIFICATIONS FOR FORM 1102.

Form as shown. Size 11x17 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

INSTRUCTIONS FOR USE OF FORM 1102.

Promptly at the close of the month the Engineer in charge of a residency or project should prepare on Form 1102 detailed estimates by stations of all grading work done by contractors. Further instructions are given under the title of the form.

(b) *Other Roadway Accounts* Form 1103

SPECIFICATIONS FOR FORM 1103.

Form as shown. Size 11x17 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

INSTRUCTIONS FOR USE OF FORM 1103.

Promptly at the close of the month the Engineer in charge of a residency or project should prepare on Form 1103 detailed estimates by stations, structures, etc., of all bridges, trestles, culverts, track laying, ballasting, fencing, automatic block signals, etc., of all such work done by contractors. Further instructions are given under the title of the form.

(c) *Buildings* Form 1104

SPECIFICATIONS FOR FORM 1104.

Form as shown. Size 11x17 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

INSTRUCTIONS FOR USE OF FORM 1104.

Promptly at the close of the month the Engineer in charge of a residency or project should prepare on Form 1104 detailed estimate by buildings or other structures of all such work done by contractors. This estimate should be made out in triplicate, forwarding the original and first carbon to the Assistant or other Engineer, his immediate superior, having general charge of the work, who will consolidate all for his line onto one form, and then forward one copy of each Resident Engineer's estimate and the consolidated estimate with Form 1105 to the Division Engineer.

(d) *Summary* Form 1105

SPECIFICATIONS FOR FORM 1105.

Form as shown. Size 11x17 inches. All lines and printing black. Perforated for binding in loose-leaf binder for permanent record after serving as report.

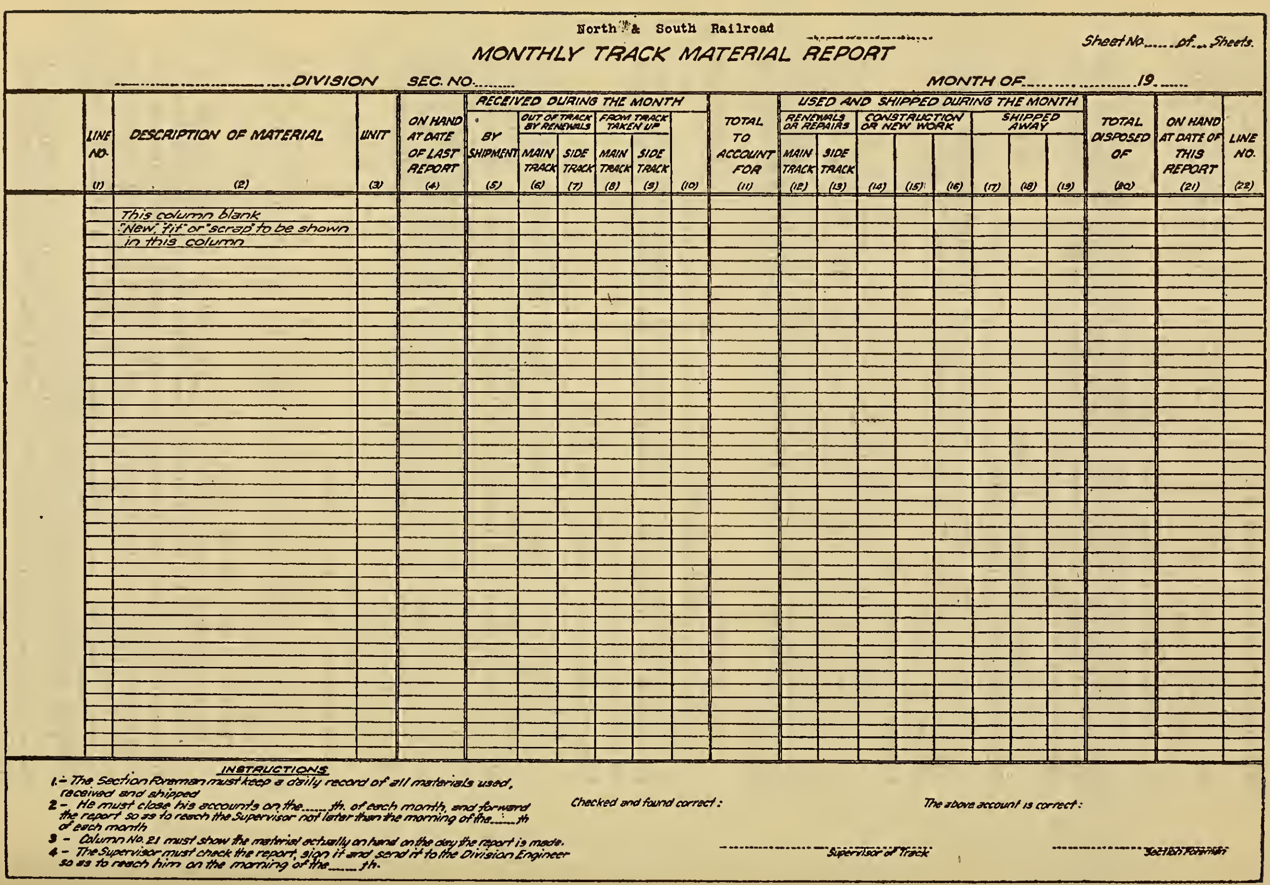
INSTRUCTIONS FOR USE OF FORM 1105.

Upon receipt of Forms 1102, 1103, and 1104, from the Resident Engineers under him the Assistant Engineer, after checking and approving, will consolidate them on forms of the same numbers and forward one copy of each with a copy of each of the Resident Engineer's estimates, together with the summary M. W. 1105, to the Division Engineer for voucher. The Division Engineer will forward Form 1105 to the Chief Engineer with the voucher covering the estimate.

As contractor's estimates are generally payable on a specified day of the month, the estimate and voucher should reach the Chief Engineer's office ten days earlier.

MONTHLY TRACK MATERIAL REPORT.

Form 1107



North & South Railroad

MONTHLY TRACK MATERIAL REPORT

Sheet No......of....Sheets.

..........................DIVISION SEC. NO........ MONTH OF....................19......

LINE NO.	DESCRIPTION OF MATERIAL	UNIT	ON HAND AT DATE OF LAST REPORT	RECEIVED DURING THE MONTH						TOTAL TO ACCOUNT FOR	USED AND SHIPPED DURING THE MONTH								TOTAL DISPOSED OF	ON HAND AT DATE OF THIS REPORT	LINE NO.
				BY SHIPMENT	OUT OF TRACK BY RENEWALS		FROM TRACK TAKEN UP				RENEWALS OR REPAIRS		CONSTRUCTION OR NEW WORK			SHIPPED AWAY					
					MAIN TRACK	SIDE TRACK	MAIN TRACK	SIDE TRACK			MAIN TRACK	SIDE TRACK									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	This column blank																				
	"New," "fit" or "scrap" to be shown																				
	in this column																				

INSTRUCTIONS

1.- The Section Foreman must keep a daily record of all materials used, received and shipped

2 - He must close his accounts on the......th. of each month, and forward the report so as to reach the Supervisor not later than the morning of the......th of each month

3 - Column No. 21 must show the material actually on hand on the day the report is made.

4 - The Supervisor must check the report, sign it and send it to the Division Engineer so as to reach him on the morning of the......th.

Checked and found correct:

..............................Supervisor of Track

The above account is correct:

..............................Section Foreman

Size 8½x11 inches. Form 1108

North and South Railroad.

______________________DIVISION

MONTHLY BRIDGE MATERIAL REPORT

______________________ Month of______________________19___

(Gang or District.)

KIND OF MATERIAL	UNIT	ON HAND FIRST OF MONTH	RECEIVED	DISPOSED OF		ON HAND END OF MONTH	REMARKS
				USED	SHIPPED AWAY		
← 2.2" →	←0.6"→	←0."7→	←0."7→	←0."7→	←0."7→	←0."7→	← 2.2" →

The above statement is correct:

....
Foreman of Bridges.

Approved:.............................. ....
Master Carpenter

Size 8½x11 inches. Form 1109

North and South Railroad.

BRIDGE SECTION TOOL REPORT

____

(Gang or District)

______________________Division. For______________ending ______________19___

TOOLS	ON HAND ___1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND	TOOLS	ON HAND ___1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND
← 2" →	←0."5→	←0."5→	←0."5→	←0."5→	←0."5→	← 1."5 →	←0."5→	←0."5→	←0."5→	←0."5→	←0."5→

The above statement is correct:

....
Foreman of Bridges.

Approved: ....
Master Carpenter

Form 1110

North and South Railroad

BRIDGE INSPECTION REPORT

_______________ Division For _______________

From _______________ To _______________ Inspected by _______________ 19__

Bridge No. or Structure	Location	Kind of Structure	Bridge Data	Date Inspected	Condition, Description of Work Required, Action Taken, or Recommendations
					(This report to be signed also by those composing inspection party)

Date _______________ 19__

Size, 11"x24"

Form 1106

A. B. & C. R. R. Co.—Side Track Record

Side Tracks on ______ Division ______ Sub-Division ______ Valuation Section

Mile Post	Location			Township or School District	Name or Number of Track	Connected or Spur	A.F.E. Number	Contract Number	Date Completed	Character of Rail Length of Service, Weight and Kind	Total, Dec. 31, 19—				Changes During Year				Remarks
	Right or Left	Station	County and State								Ownership			Total	Ownership			Total	
											Railroad		Private		Railroad		Private		
											InCorp. Limits	In County			InCorp. Limits	In County			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Amount brought forward.																			
Amount carried forward.																			

B. Maintenance Reports and Records.

1. Track:

(a)	*Side Track Record*	Form 1106
(b)	*Monthly Track Material Report*	Form 1107

Specifications for Form 1107.

Form as shown. Size 11x17 inches. Six horizontal lines per inch. All lines and printing black.

Instructions for use of Form 1107.

Instructions for the use of this form are given at the bottom of the form.

2. Bridges and Buildings:

(a) *Monthly Bridge Material Report* Form 1108

Specifications for Form 1108.

Form as shown. Size 8½x11 inches. Three horizontal lines per inch. All lines and printing black.

Instructions for use of Form 1108.

Foremen are required to make the above report.................. and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

(b) *Bridge Section Tool Report* Form 1109

Specifications for Form 1109.

Form as shown. Size 8½x11 inches. Three horizontal lines per inch. All lines and printing black.

Instructions for use of Form 1109.

Foremen are required to make the above report.................. and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

(c) *Bridge Inspection Report* Form 1110

Specifications for Form 1110.

Form as shown. Size 11x8½ inches. All lines and printing black.

Instructions for use of Form 1110.

In Bridge Inspection there should be a clear distinction made between General Inspection and Current Inspection.

The purpose of the General Inspection, frequently called the annual inspection, although in many cases conducted semi-annually or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important bridges and structures on the entire road, and, further, to ascertain and determine what extensive repair work or renewal work should be done in the following working season.

Numerous minor special forms are used on all railways for reporting information necessary to keep bridge records up to date, but such forms should be regulated by each individual railway according to its peculiar requirements.

Bridge records, when properly kept up to date in an accurate manner, will prove of the highest value to railways and have become essential because of recent legislation.

Size 4x6 inches. Form 1111

Report No.__________

North and South Railroad.

____________________Division

CURRENT BRIDGE INSPECTION REPORT

I have to-day inspected____

at ____

and find its condition as follows:

____

____

The following work is required to maintain structure in good condition:

____

____

The following work must be done to keep the structure safe:

____

____

____

Inspector.

Date,__________________________19

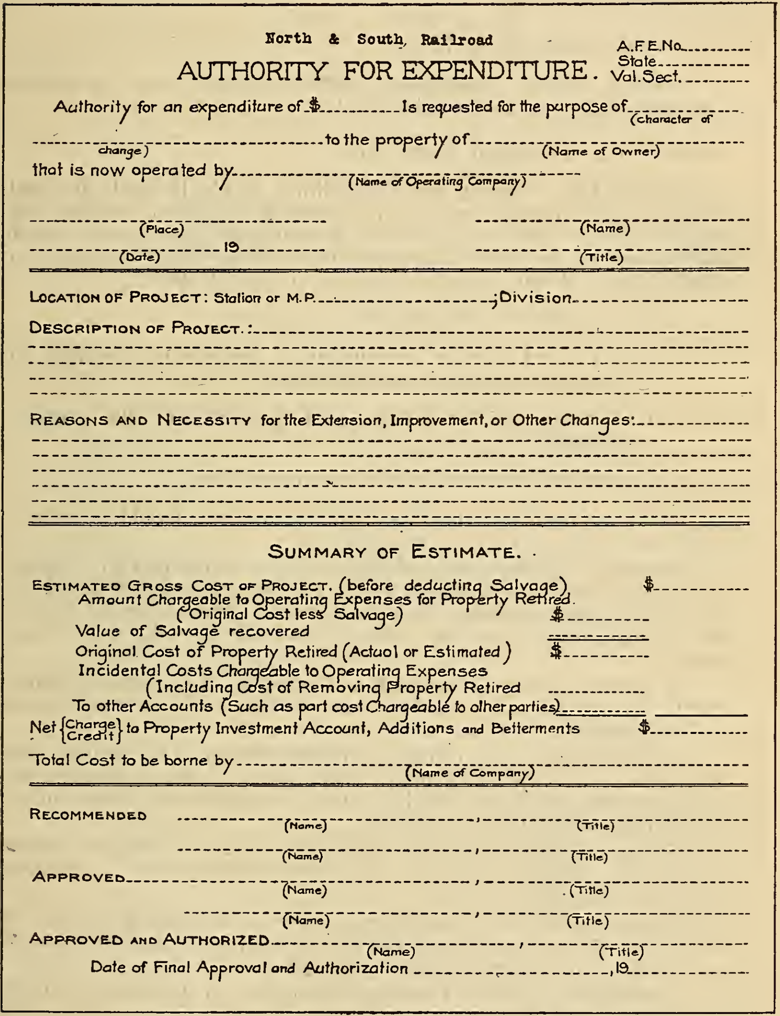
Note.—Make separate report for each bridge or structure inspected. Send report to the______________of the Division. Report by telegraph to the______________and the Superintendent of the Division all serious defects that require attention.

(c) *Current Bridge Inspection Report* Form 1111

Form as shown. Size 4x6 inches. Printed on manila cardboard, addressed on the reverse side to the proper official.

To be sent as a postal report. The purpose of the Current Inspection, clearly distinguished from the General Inspection, is to keep the structure in safe condition, to discover any defects and to report the same promptly, so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and that the superior officer be kept advised of all such inspections, whether made by a Bridge Mechanic, Gang Foreman, Division Bridge Inspector, Master Carpenter or others.

Form 1113



North & South Railroad

A.F.E.No.----------
State-------------
Val.Sect.----------

AUTHORITY FOR EXPENDITURE.

Authority for an expenditure of $---------- Is requested for the purpose of -------------- (character of change) ------------------------ to the property of ------------------ (Name of Owner) ------------------
that is now operated by ------------------ (Name of Operating Company) ------------------

---------------- (Place) ----------------
------------ (Date) ------------ 19------------

---------------- (Name) ----------------
---------------- (Title) ----------------

LOCATION OF PROJECT: Station or M.P. ------------------; Division ------------------

DESCRIPTION OF PROJECT.: ------------------------------------

REASONS AND NECESSITY for the Extension, Improvement, or Other Changes: ------------------------

SUMMARY OF ESTIMATE.

ESTIMATED GROSS COST OF PROJECT. (before deducting Salvage)		$----------
Amount Chargeable to Operating Expenses for Property Retired. (Original Cost less Salvage)	$----------	
Value of Salvage recovered	----------	
Original Cost of Property Retired (Actual or Estimated)	$----------	
Incidental Costs Chargeable to Operating Expenses (Including Cost of Removing Property Retired	----------	
To other Accounts (Such as part cost Chargeable to other parties)	----------	----------
Net {Charge / Credit} to Property Investment Account, Additions and Betterments		$----------

Total Cost to be borne by ------------------ (Name of Company) ------------------

RECOMMENDED ---------- (Name) ----------, ---------- (Title) ----------
---------- (Name) ----------, ---------- (Title) ----------

APPROVED ---------- (Name) ----------, ---------- (Title) ----------
---------- (Name) ----------, ---------- (Title) ----------

APPROVED AND AUTHORIZED ---------- (Name) ----------, ---------- (Title) ----------

Date of Final Approval and Authorization ------------------, 19------------

5. APPRAISALS, VALUATION RECORDS AND ACCOUNTING:

(a) *Authority for Expenditure* Form 1113

Construction, addition or betterment work should be authorized in accordance with a reasonable and simple system, involving the preparation of estimates of cost and the formal authorization of the expense by executive officers.

SPECIFICATIONS FOR FORM 1113.

Form as shown. Size 8½x11 inches. Printed on white medium bond paper; all lines and printing black.

INSTRUCTIONS FOR USE OF FORM 1113.

Request for Authority for Expenditure should be made for each change in the railroad's property involving an extension, addition, betterment, transfer of class of service, or retirement from service which, when signed by the highest approving officer, becomes an Authority for Expenditure. When properly prepared it should show:

1. The location of the project.
2. A brief and concise description of the project showing the character, magnitude and extent of the work.
3. Explanation of the reasons and necessity for the proposed changes.
4. Summarized distribution of the estimated cost.

So far as possible Authorities for Expenditure should be secured in advance of the changes in the property.

Involuntary changes in fixed property, such as destruction by storm, flood or fire, and other changes effected by emergency should be covered by an AFE as soon thereafter as possible. AFE's covering the destruction of equipment should be made for each class at the end of each month.

A sketch showing the location and extent of the proposed changes should accompany and be made a part of the AFE covering changes in fixed property.

AFE's should never overlap valuation sections. If a project, such as relaying rail, extends through or into two or more valuation sections, separate AFE's should be secured covering the changes in the property in each valuation section.

The expenditures under an AFE must be kept within the amount authorized. Supplementary and additional Authority must be obtained in case of necessity.

The authority should be made to expire at the end of the year in which issued. If work is incomplete at that time, a new Authority should be issued for the following year's expenditures.

A detailed estimate of the classified cost of the project should be prepared and accompany the Request for Authority. When the estimate is based upon plans, always refer to the numbers and dates of the plans.

Observe the following rules in describing projects:

(a) When additional buildings or other structures are to be built, begin your description with the word "New."

(b) When a building or other structure is to be built to replace an inferior one, or one of different kind, begin your description with the word "Replacing."

(c) In case of replacement, mention should be made of any variation from the original construction, such as:
Substituting stone for frame building.
Steel for wooden bridge, etc.

(d) When a building or other structure is reconstructed, retiring the original, use the word "Renewing."

(e) Under other conditions use a suitable word, such as:

Strengthening	(Bridges)
Changing	(Yard Tracks)
Altering	(Buildings)
Extending or widening	(Wharves)

Improvement at (consisting of new 20x40 foot frame passenger station, renewing 30x50 foot standard frame freight station, altering yard tracks, strengthening bridges, etc.)

Credits: When including in the estimate material which is to be used in temporary work, allow (under head of "Credits") an amount to cover estimated value of material to be recovered.

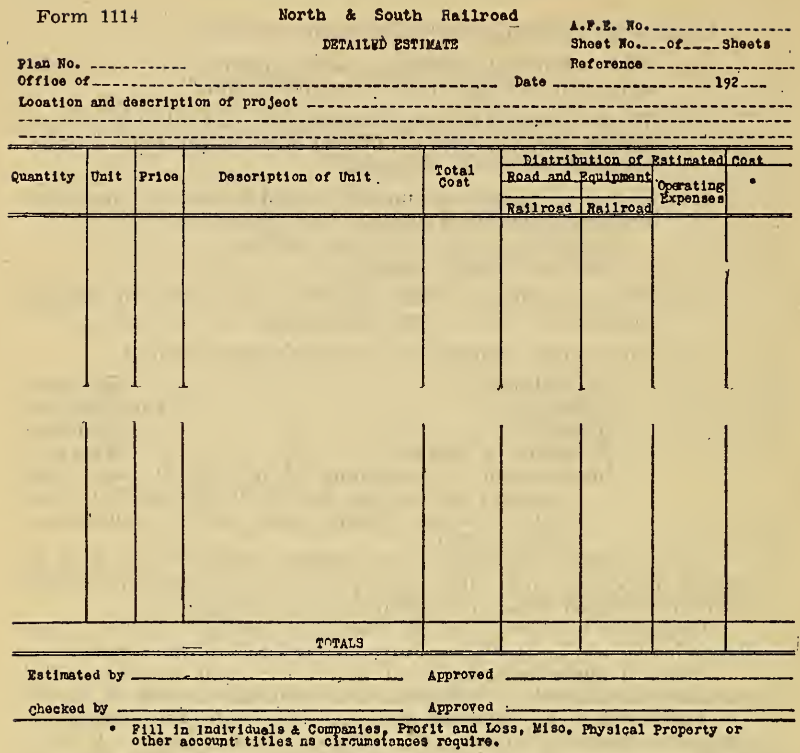
Disposition to be made of the abandoned buildings or other structures should be shown, if necessary, on the back of the form.

Dates of agreements, names of parties, etc., that are to be billed for items distributed to individuals and companies should be shown.

This form to be submitted in................by the original officer to the approving officer. (The initiation and submission of R. F. A. papers as per special instructions of individual roads.) If the Request for Authority is approved, designating number should be given and notice thereof should be sent out to all interested officials.

Estimates should be numbered for identification. When properly prepared they should show:

1. Reference to the plan number.
2. A brief and concise description and location of the work covered by the estimate.
3. Estimate of cost in detail.
4. Credits, if any, for material to be recovered, etc., such as salvage from false-work, temporary tracks, and in case of a renewal on account of fire the amount of insurance recovered, and anything else that is a proper credit to the job.
5. Distribution of estimated cost as between new work, Betterments, Renewals or Replacements and Individuals and Companies.
6. Estimate will be signed by the maker and approved by various officers in accordance with the prevailing organization.
7. Reproduction cost of any building or other structure which is to be replaced. This information will be required by the officer determining the distribution of the expense.



Form 1114

North & South Railroad

DETAILED ESTIMATE

A.F.E. No.________________

Sheet No.___of____Sheets

Reference ________________

Plan No. ____________

Office of____ Date ________________192__

Location and description of project ____

Quantity	Unit	Price	Description of Unit	Total Cost	Distribution of Estimated Cost			
					Road and Equipment		Operating Expenses	*
					Railroad	Railroad		
			TOTALS					

Estimated by ____________________ Approved ____________________

Checked by ____________________ Approved ____________________

* Fill in Individuals & Companies, Profit and Loss, Misc. Physical Property or other account titles as circumstances require.

(b) *Detailed Estimate* Form 1114

SPECIFICATIONS FOR FORM 1114.

Form as shown. Size 8½x11 inches. Printed on white light bond paper; all lines and printing black.

INSTRUCTIONS FOR USE OF FORM 1114.

Each Request for Authority for Expenditure should be accompanied by a detailed estimate of the project on this form, unless the proposed change in the property is so small and so simple that it is deemed unnecessary to show the details of the estimate. It should be signed by the maker and approved by various officers in accordance with the prevailing organization. One copy to be attached to each copy of the AFE.

A complete estimate on this form should show:

1. Reference to the plan, if any—date, number and origin.
2. A brief and concise description and location of the project.
3. Estimate of cost in detail.
4. Credits, if any, for material to be recovered, etc., such as salvage from false-work, temporary tracks, and in case of a renewal on account of fire the amount of insurance recovered, and anything else that is a proper credit to the project.
5. Distribution of estimated cost as between Additions, Betterments, Renewals, Replacements, Retirements and between Other Companies and Individuals.
6. Ledger value, estimated if not known, of property which is to be retired.

Form 1115

North & South Railroad

REGISTER OF AUTHORITIES FOR EXPENDITURE.

Valuation Engineer's File No.	AUTHORITY				LOCATION		DESCRIPTIVE TITLE.	DATE OF WORK		Completion Report Received.	TOTAL COSTS		REMARKS
	A. F. E.		D.C.E.										
	No.	Date	Form	No.	State	Val. Sec.		Beginning	Completion		Estimated	Actual	
											$	$	

Form 1116

__________________________RAILWAY

MONTHLY REPORT OF EXPENDITURES

MONTH OF________________19_____

DESCRIPTIVE TITLE OF WORK ____

AUTHORITY { No.__________ Date______________19___ Amount $ __________________

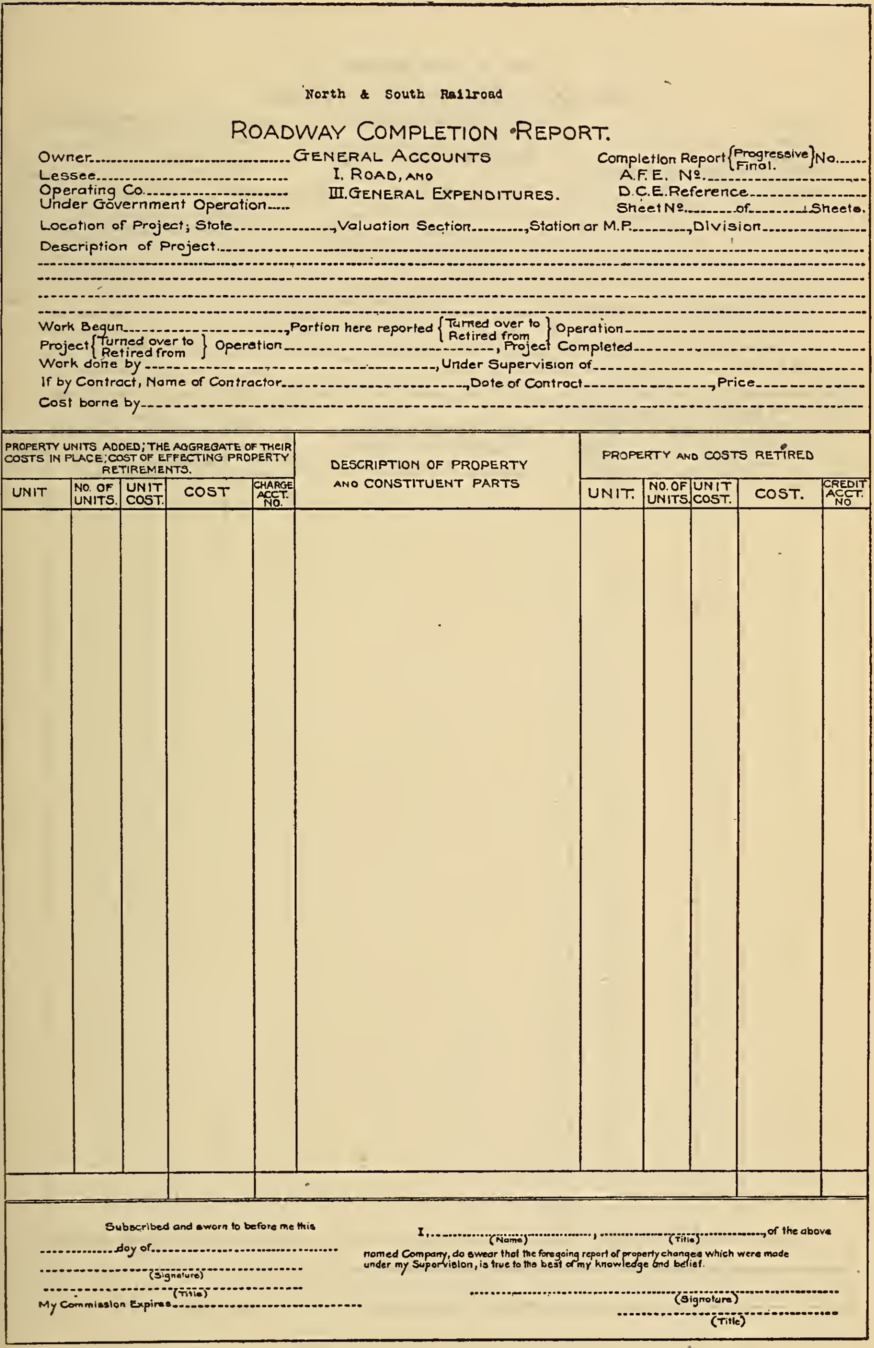
DATE OF WORK { Beginning ________________19___ Completion ________________19___

LOCATION { State _______________ Valuation Section No.____ Station _______________

	AUTHORIZED APPROPRIATION	EXPENDED This Month	EXPENDED Previous	EXPENDED Total to Date
I. ROAD				
1. Engineering	$	$	$	$
2 Land for transportation purposes				
3 Grading				
4 Underground Power Tubes				
5 Tunnels and Subways				
6 Bridges, Trestles and Culverts				
7 Elevated Structures				
8 Ties				
9 Rails				
10 Other Track Material				
11 Ballast				
12 Track Laying and Surfacing				
13 Right-of-Way Fences				
14 Snow and Sand Fences and Snowsheds				
15 Crossings and Signs				
16 Station and Office Buildings				
17 Roadway Buildings				
18 Water Stations				
19 Fuel Stations				
20 Shops and Enginehouses				
21 Grain Elevators				
22 Storage Warehouses				
23 Wharves and Docks				
24 Coal and Ore Wharves				
25 Gas Producing Plants				
26 Telegraph and Telephone Lines				
27 Signals and Interlockers				
28 Power Dams, Canals and Pipe Lines				
29 Power Plant Buildings				
30 Power Substation Buildings				
31 Power Transmission Systems				
32 Power Distribution Systems				
33 Power Line Poles and Fixtures				
34 Underground Conduits				
35 Miscellaneous Structures				
36 Paving				
37 Roadway Machines				
38 Roadway Small Tools				
39 Assessments for Public Improvements				
40 Revenues and Oper. Exp. During Construction				
41 Cost of Road Purchased				
42 Reconstruction of Road Purchased				
43 Other Expenditures – Road				
44 Shop Machinery				
45 Power Plant Machinery				
46 Power Substation Apparatus				
47 Unapplied Const. Mat'l and Supplies				
II. EQUIPMENT				
51 Steam Locomotives				
52 Other Locomotives				
53 Freight-train Cars				
54 Passenger-train Cars				
55 Motor Equipment of Cars				
56 Floating Equipment				
57 Work Equipment				
58 Miscellaneous Equipment				
III. GENERAL EXPENDITURES				
71 Organization Expenses				
72 General Officers and Clerks				
73 Law				
74 Stationery and Printing				
75 Taxes				
76 Interest During Construction				
77 Other Expenditures – General				
CHARGED OPERATING EXPENSES				
TOTAL EXPENDED		$	$	$
APPROPRIATION	$			
BALANCE		$	$	$

______(Dated at)______________________(Date)__________19___ _______________General Auditor or Comptroller

Form 1117



North & South Railroad

ROADWAY COMPLETION REPORT.

Owner.................................... GENERAL ACCOUNTS Completion Report {Progressive / Final.} No.......
Lessee.................................... I. ROAD, AND A.F.E. Nº.......................
Operating Co............................ III. GENERAL EXPENDITURES. D.C.E. Reference.......................
Under Government Operation..... Sheet Nº.........of.........Sheets.

Location of Project; State..................., Valuation Section.........., Station or M.P.........., Division....................

Description of Project...

....

....

....

....

Work Begun.............................., Portion here reported {Turned over to / Retired from} Operation..............................

Project {Turned over to / Retired from} Operation.............................., Project Completed..............................

Work done by.............................., Under Supervision of..............................

If by Contract, Name of Contractor.............................., Date of Contract...................., Price....................

Cost borne by..

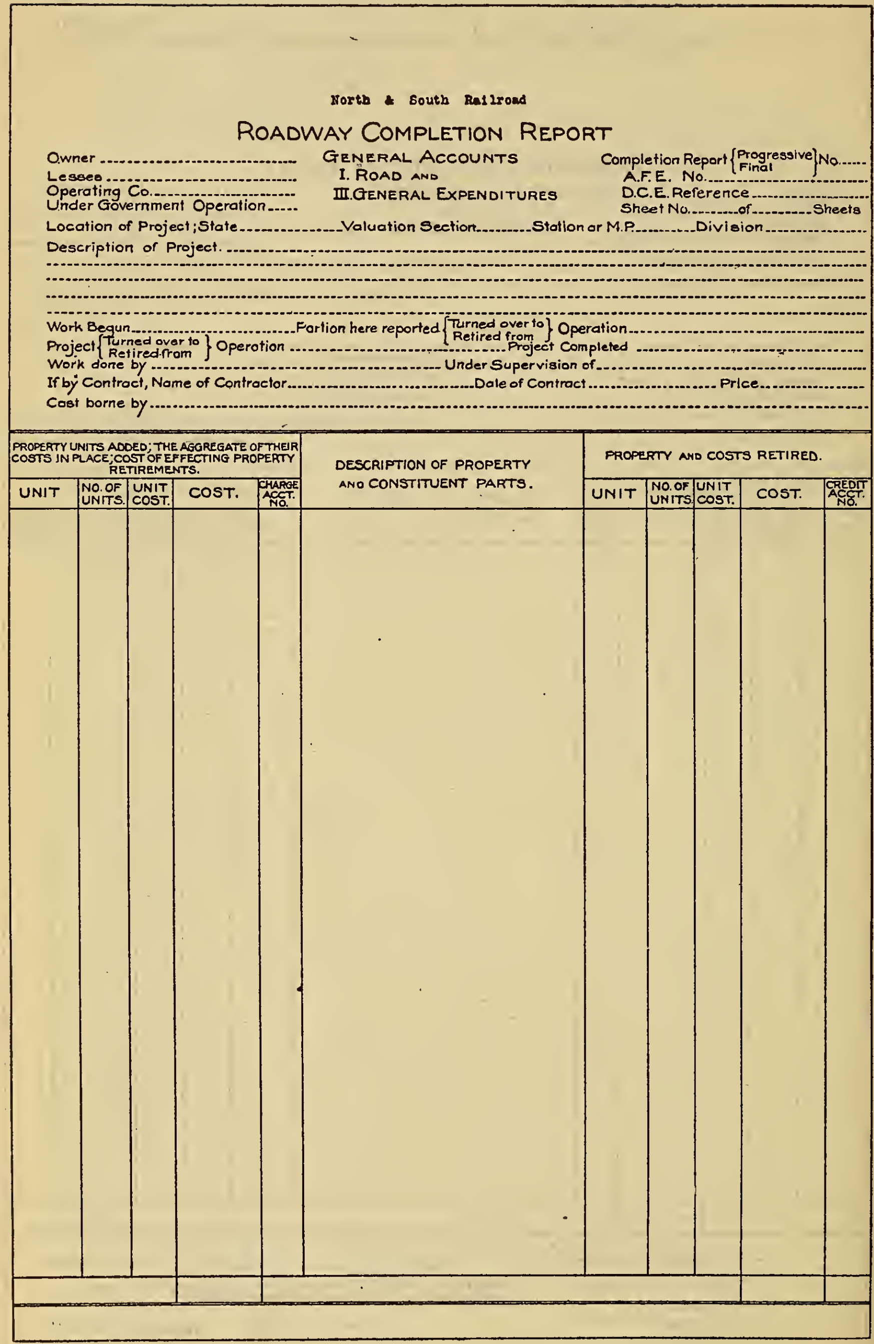
PROPERTY UNITS ADDED; THE AGGREGATE OF THEIR COSTS IN PLACE; COST OF EFFECTING PROPERTY RETIREMENTS.					DESCRIPTION OF PROPERTY AND CONSTITUENT PARTS	PROPERTY AND COSTS RETIRED				
UNIT	NO. OF UNITS.	UNIT COST.	COST	CHARGE ACCT. NO.		UNIT.	NO. OF UNITS.	UNIT COST.	COST.	CREDIT ACCT. NO

Subscribed and sworn to before me this
..................day of.......................................
....
(Signature)
....
(Title)
My Commission Expires.......................................

I,.............................., ..., of the above
(Name) (Title)
named Company, do swear that the foregoing report of property changes which were made under my Supervision, is true to the best of my knowledge and belief.

....
(Signature)
....
(Title)

Form 1117-A



North & South Railroad

ROADWAY COMPLETION REPORT

Owner ....
Lessee ....
Operating Co. ....
Under Government Operation .....

GENERAL ACCOUNTS
I. ROAD AND
III. GENERAL EXPENDITURES

Completion Report {Progressive / Final} No. ......
A.F.E. No. ....
D.C.E. Reference ....
Sheet No. .... of .... Sheets

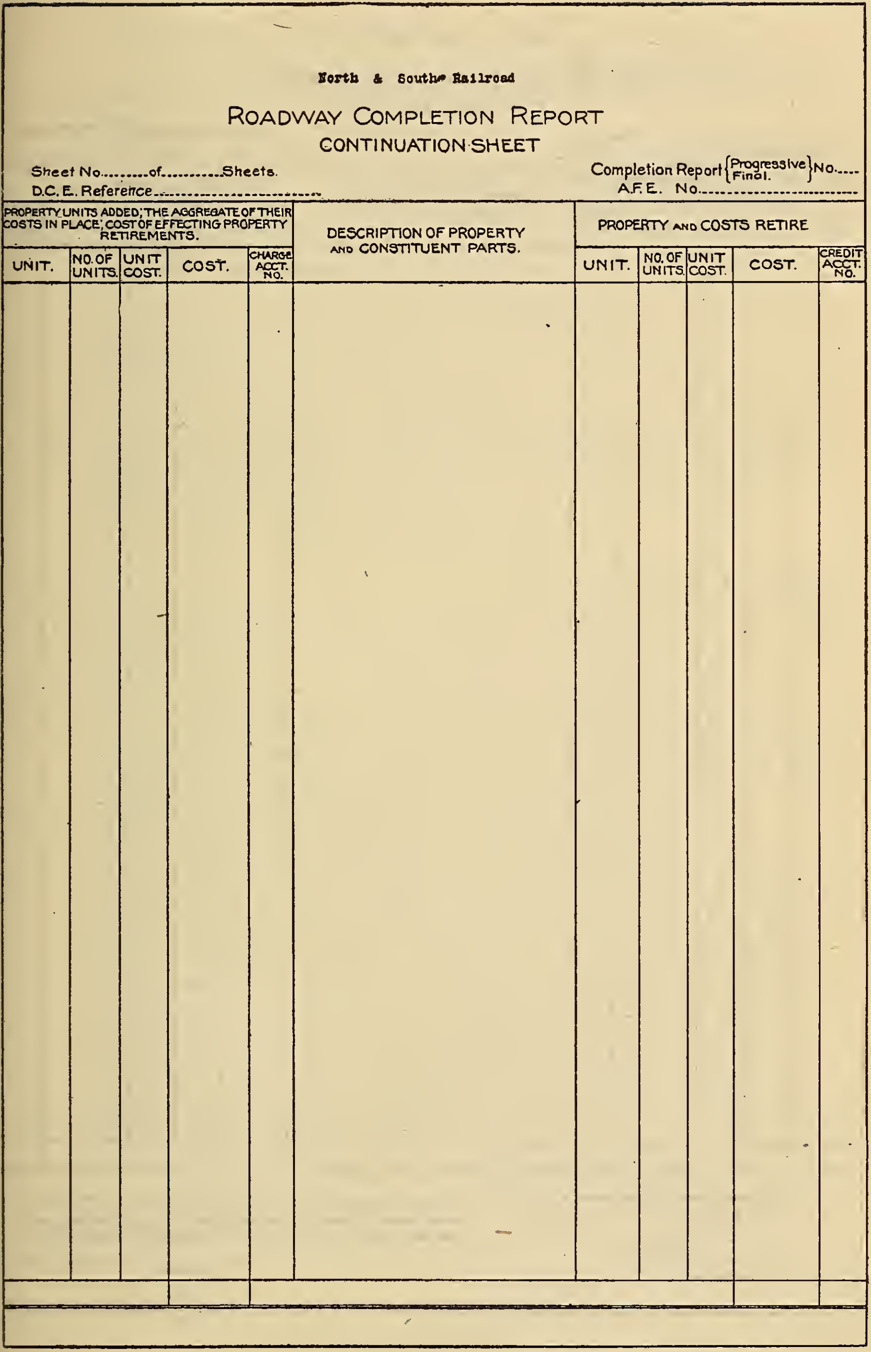
Location of Project; State .... Valuation Section .... Station or M.P. .... Division ....

Description of Project. ....

Work Begun .... Portion here reported {Turned over to / Retired from} Operation ....
Project {Turned over to / Retired from} Operation .... Project Completed ....
Work done by .... Under Supervision of ....
If by Contract, Name of Contractor .... Date of Contract .... Price ....
Cost borne by ....

PROPERTY UNITS ADDED; THE AGGREGATE OF THEIR COSTS IN PLACE; COST OF EFFECTING PROPERTY RETIREMENTS.					DESCRIPTION OF PROPERTY AND CONSTITUENT PARTS.	PROPERTY AND COSTS RETIRED.				
UNIT	NO. OF UNITS.	UNIT COST.	COST.	CHARGE ACCT. NO.		UNIT	NO. OF UNITS.	UNIT COST.	COST.	CREDIT ACCT. NO.

Form 1117-B



North & South Railroad

ROADWAY COMPLETION REPORT

CONTINUATION SHEET

Sheet No.........of...........Sheets.
D.C.E. Reference..........................

Completion Report {Progressive / Final.} No.....
A.F.E. No..........................

PROPERTY UNITS ADDED; THE AGGREGATE OF THEIR COSTS IN PLACE; COST OF EFFECTING PROPERTY RETIREMENTS.					DESCRIPTION OF PROPERTY AND CONSTITUENT PARTS.	PROPERTY AND COSTS RETIRE				
UNIT.	NO. OF UNITS.	UNIT COST.	COST.	CHARGE ACCT. NO.		UNIT.	NO. OF UNITS.	UNIT COST.	COST.	CREDIT ACCT. NO.

Form 1117-C

North & South Railroad

ROADWAY COMPLETION REPORT.

CONTINUATION SHEET.

Sheet No.............of...............Sheets

D.C. E. Reference..

Completion Report {Progressive / Final.} No......

A.F.E. No...

PROPERTY UNITS ADDED; THE AGGREGATE OF THEIR COSTS IN PLACE; COST OF EFFECTING PROPERTY RETIREMENTS.					DESCRIPTION OF PROPERTY AND CONSTITUENT PARTS.	PROPERTY AND COSTS RETIRED.				
UNIT.	NO. OF UNITS	UNIT COST.	COST.	CHARGE ACCT. NO.		UNIT.	NO. OF UNITS	UNIT COST.	COST.	CREDIT ACCT. NO.

Subscribed and sworn to before me this

..............day of ...., 19 ....

....
(Signature)

....
(Title)

My Commission Expires..............................

I, ..., ..., of the above
(Name) (Title)
named Company, do swear that the foregoing report of property changes, which were made under my Supervision, is true to the best of my knowledge and belief.

....
(Signature)

....
(Title)

(c) *Register of Authorities for Expenditure* Form 1115

SPECIFICATIONS FOR FORM 1115.

Form as shown. Size 14x17 inches. Printed on white medium ledger paper; all lines and printing black. Horizontal lines five to the inch.

INSTRUCTIONS FOR USE OF FORM 1115.

As each project is authorized, the number, date, location, description and estimated cost should be entered on this form in order of the numbers assigned. As the completion reports are submitted the remaining information called for on the form should be entered at once.

This form is designed to be kept in a loose-leaf binder. One book should be kept for each owning company.

(d) *Monthly Report of Expenditures* Form 1116

SPECIFICATIONS FOR FORM 1116.

Form as shown. Size 8½x14 inches. All lines and printing black.

INSTRUCTIONS FOR USE OF FORM 1116.

Upon closing the accounts for each month the chief accounting officer should submit a statement of expenditures of each project in course on Form 1114 in .... to the Chief Engineer, or other officer in charge of the work.

(e) *Roadway Completion Report*

Forms 1117-1117A-1117B-1117C

SPECIFICATIONS FOR FORMS 1117, 1117A, 1117B, 1117C.

Form as shown. Size 11x17 inches. All lines and printing black.

INSTRUCTIONS FOR USE OF FORMS 1117, 1117A, 1117B, 1117C.

A report must be made on this form for each project by the Engineer or other officer in charge, as soon after completion as possible, showing in detail the changes made in the property, listing the units of property added and their costs and the units of property retired and their costs, and classified by accounts, and forward to the Chief Engineer, Valuation Engineer, or other designated officer.

A tracing must be made to accompany this form with notes showing location and extent of all new tracks laid; of old ones changed or removed; of bridges, buildings, platforms, stockyards, right-of-way fences, etc., built, changed, removed, or destroyed by fire, with date of fire. Measurements must be made to connect new work with definitely located points. Make tracing 11 inches wide, and if convenient, 17 inches long, or multiple of one only of these dimensions when necessary to show extensive work. Tracing should show both plan and profile or elevation of new tracks, bridges, buildings, etc. Show property of the company not changed under the improvement being reported by full black lines; property of the company removed, abandoned or destroyed, by dotted black lines; property of the company added, or new location, by full red lines; proposed but uncompleted work of the company by dotted red lines; and property of other railroads by other colors.

Care must be exercised in formulating the description of project to show the character, extent and magnitude of the change in property covered by the report.

Form 1118

Sheet No. ....of ....Sheets

North & South Railroad

COMPLETION REPORT
OF
CHANGES MADE IN EQUIPMENT DURING THE SIX MONTHS ENDED........................19....
General Account 11. Equipment.

Authority	Equipment, unit numbers, names or series affected by the change.	Owner	Lessee.	Description of Equipment to which the change is applicable.	Total number of units affected.	Description of the change effected and of the other items contributing to the costs incurred.	Date of Change	COSTS INCURRED		COSTS RETIRED	
A. F. E. No.								Dr. Acct. No.	Amount	Cr. Acct. No.	Amount

I, ... (Name) .... (Title) of the above named company do swear that the foregoing report of property changes which were made under my supervision is true to the best of my knowledge and belief

Subscribed and sworn to before me this.............day of ....19.....

.... (Signature)

.... (Title) My Commission Expires..................................

.... (Signature)

.... (Title)

(f) *Equipment Completion Report* Form 1118

Specifications for Form 1118.

Form as shown. Size 11x17 inches. All lines and printing black.

Instructions for use of Form 1118.

A report must be prepared on this form for each equipment project by the designated officer, as soon after completion as possible, listing and describing the units of equipment affected and giving careful description of the changes made and listing the units involved, both added and retired, with the costs of each. If a project involves changes in a number of units completed in more than one six months' period a progress report should be made covering the changes completed in each six months' period. When the whole project is finished a final report should be prepared covering all the changes made under the AFE which will be a summary of all the semi-annual progress reports.

6. Labor and General Forms.

(a) *Time Roll* Form 1119

Specifications for Form 1119.

Form as shown. Size of book, 5½x8½ inches. Cover to be of three-ply manila paper, book proper to be on yellow paper; printing to be in black. Book to contain 12 pages. Form shown is reduced size.

Form 1119

NORTH AND SOUTH RAILROAD

*SUBDIVISION No.*__________

TIME ROLL

of

*SECTION No.*__________ *or*______________________________
(Name or Number of Gang)

______________________ *Month of*____________________ *19*____
HEADQUARTERS

I hereby certify that the within returns are correct:

Examined and found correct: ______________________________
FOREMAN

*Supervisor of*______________________________

DAILY RECORD OF. TIME

(Name of Railroad)

RECORD OF TIME FOR THE MONTH OF ______________ 19__

Badge No.	Name	Occupation	Periods																Total		Rate		Amount Earned	Totals	Deductions			Total Paid	Pay 1st Period	Pay 2nd Period	Time Check Number
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		Month	Hours	Per Mo.	Per Hr.			Account	Amount	To Whom Paid				
			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31													
	Regular Overtime Overtime (Penalty)																														
	Regular Overtime Overtime (Penalty)																														

1. Spell names correctly. Write out first name and give middle initial. Enter check number in check number column.

2. Write "Paid by Certificate," when men have been so paid. If hired again, enter name a second time.

3. Amounts due each man must be in even five (5), or ten (10) cents.

4. Time of monthly men, not working a full month: Multiply the rate per month by the number of days worked (including Sundays and holidays) and divide by the total number of days in the month.

INSTRUCTIONS.

1. Enter the information daily.
2. Read the instructions at the bottom of pages 2 and 3.
3. Show under each day the hours of work of each kind done, including work done by Foreman.
4. The Summary on pages 14 and 15 must show all the work done during the month. It is obtained by collecting the work done each day. Show separately work done on main tracks, sidings, new or construction work of all kinds and for individuals or other companies.
5. The total hours each day must agree with the totals shown on pages 2, 3, 4, 5, 6 and 7.
6. The total of hours in Summary must agree with the total on page 7.

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HOURS
1		
2		
3		
4		
5		

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HRS.
31		

SUMMARY OF WORK DONE FOR MONTH

ITEMS	DISTR.	HOURS	RATE	AMOUNT

I certify the foregoing to be correct,

____________________*Foreman.*

Examined and approved,

____________________*Supervisor.*

Note.—Spaces to be provided for 31 days.

Form 1120

CONTRACT AND LEASE RECORD.

CONTRACTS AND LEASES

100 Pages

Number	Name of Road	With Whom	Nature of Document		Date	Expires	No. of Canceled Contract	Memoranda

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

50 Pages

Number	Name of Road	With Whom	Receipt	When taken	When returned		Number	Name of Road	With Whom	Receipt	When taken	When returned

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

6 Pages

JANUARY																		FEBRUARY																
1897	1898	1899	1900	1901	1902	1903	1904	1905	1908	1907	1908	1909	1910	1911	1912	1913		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913

(b) *Contract and Lease Record* Form 1120

SPECIFICATIONS FOR FORM 1120.

The Custodian of Leases should keep a Contract and Lease Record Book, containing in the body of the book a full record of the lease in accordance with the form illustrated.

In the back part of the book twelve pages for the twelve months should be ruled into columns for years.

INSTRUCTIONS FOR USE OF FORM 1120.

Leases should be numbered and filed in numerical order, by road, branch or division, in a fireproof vault.

Immediately after the receipt of a lease it is entered in the body of the book; the lease number should be entered under the year on the proper month page when it expires.

The names of the lessees should be indexed alphabetically in the front of the book, and each lease should be indexed by the station name.

A few pages in the back of the book should be used for the purpose of keeping a record of the leases removed from the files.

A receipt should be required for each contract or lease removed from the files.

(c) *Register of Title Deed*

D. V. Forms 107 and 108 were prescribed by Order No. 7, Bureau of Valuation, Interstate Commerce Commission, and it is recommended that these forms be kept up to date for a Register of Title Deeds.

[3] MAPS, CHARTS AND PROFILES.

(a) *Specifications for Maps and Profiles.*

SIZE.

Right-of-Way and Track Maps.

Twenty-four inches by 56 inches; single-line border 23 inches by 55 inches.

Station Maps.

Twenty-four inches by 56 inches; single-line border 23 inches by 55 inches. When more than one sheet is required to show a station property, the plat shall be made upon "matched marked" sheets in such manner as to require the minimum number.

Record Profiles.

Plate "A" tracing cloth 12 inches by 56 inches; single-line border 10 inches by 55 inches.

All other sizes of drawings to be determined by each individual road and to be as far as possible multiples of correspondence size or other basic units.

SCALES.

Masonry and Building Plans.

One-eighth inch, ¼ inch or ½ inch equals one foot.

Detail Plans of Buildings.

Scales should depend upon character of plans.

Right-of-Way and Track Maps.

One inch equals 100 feet, or 200 feet or 400 feet, but the same scale should be used throughout each Valuation Section.

Station Maps and Track Layouts.

One inch equals 100 feet, or, in complicated situations, one inch equals 50 feet.

Individual Right-of-Way Maps.

One inch equals 200 feet, 100 feet or 50 feet, as may be necessary.

Maps of Surveys.

One inch equals 400 feet or 200 feet when practicable, and when necessary one inch equals 100 feet. Reductions of same, one inch equals 1000 feet.

Profiles.

Plate "A" vertical, one inch equals 20 feet; horizontal, one inch equals 400 feet, except on ballast profiles, the vertical scale to be one inch equals 4 feet.

Condensed Profiles.

Vertical, one inch equals 200 feet; horizontal, one inch equals one mile, except where other scales are necessary.

---

[3] Adopted, Vol. 18, 1917, pp. 759-768; Vol. 19, 1918, pp. 209, 1105.

Track Charts.

Horizontal, one inch equals one-half mile; vertical, one inch equals 100 feet or 400 feet.

TITLES.

The title to be placed as near the lower right-hand corner as practicable.

The following information to be shown for right-of-way and track maps, station maps and record profiles:

- (1) Class.
  - (a) Right-of-way and track map.
  - (b) Station map.
  - (c) Profile.
- (2) Corporate name of railway.
- (3) Name of operating company.
- (4) Name of railway division or branch line.
- (5) Beginning and ending of survey station numbers on sheet.
- (6) Scale or scales.
- (7) Date as of which maps or profiles represent the facts shown thereon.
- (8) Office from which issued.

Titles for all other drawings to conform to the practice of each individual road.

A note referring to drawings, note-books or other data used in compiling to be shown on each drawing.

ORIENTATION.

The tops of maps should be to the north or east, according as the general direction of the line is east and west, north or south.

(The existing stationing to be preserved wherever practicable, adjacent stationing being extended in the same direction over unstationed intervals.)

On each end of each sheet there shall be shown a pointer directing to a terminal or important station.

SYMBOLS.

The symbols used on all maps, profiles and plans shall be the standards recommended by the American Railway Engineering Association, in so far as they may be applicable.

CARDINAL POINTS.

On all maps an arrow showing the true north and south line (as nearly as can be ascertained from existing records) shall be placed.

COLORS.

On all maps and profiles to be submitted to the Interstate Commerce Commission, black only shall be used, except that the ruling of profiles shall be in orange ink.

INFORMATION TO BE SHOWN.

Maps of Surveys.

Show all surveyed lines; points of curve to be marked by radical lines, on which stations and plusses are to be given. Legends to be placed between the radical lines, giving the degree and central angle of simple curve and central angle of each spiral. Also show the contours where necessary at intervals of five (5) feet; all streams, rivers, etc., indicating direction of current of same by arrow, and approximate area of opening required. Also property lines, buildings of all kinds, pole and pipe lines, fences, roads, existing railroads, bridges, drains, sewers, manholes, conduits, culverts, areas of existing openings below high-water marks and any other necessary data within the limits of the survey. Names of cities, towns, and stations; county, township and state lines to be distinctly marked. The distance from each end of the survey to some point easily located on country or state map, or when survey connects with an existing railroad, name of and distance to nearest station to be given.

Where tracks are shown, points of switches and points of frogs to be marked, and frog numbers noted.

When they are extensive, surveys are to be plotted by co-ordinates determined by observations taken every seven (7) miles easting or westing on location and every fifteen (15) miles on preliminary work; corrections of one minute (0° 1′) for every 7000 feet of easting or westing shall be made in bearings for convergence of meridian, the first correction to be made at a convenient point about 3000 feet from point of observation. If the bearings of the tangent at the point where the correction is to be made is northeast or northwest, add one minute (0° 1′) for correction of azimuth; if it is southeast or southwest, subtract one minute (0° 1′).

Both bearings shall be shown on the tangent whose bearing is corrected and "(0° 1′) added (or subtracted) for correction of azimuth" shall be marked along the meridian through the point of correction. Corrected bearings shall be accepted as the true bearings of lines.

Profiles of Surveys.

Show ground lines, surface of streams, rivers, etc., depth of same, elevations of high and low water line, sub-grade lines showing rate of grade and elevations at all points of change of rate, and station numbers.

One line below profile show alinement using full line for tangents and broken lines for curves, showing degree of direction of same, total deflection and plusses at beginning and ending of simple curves and spirals.

Divisional lines shall be shown on this alinement, and names of property owners.

Give distances from ends of profile to nearest city, town or station.

When estimates are shown, note width of roadbeds and list quantities in cuts and fills, tunnels, bridges, pipes, crossings, etc., classified in the order given on estimate sheets. Also table of quantities for each section.

All elevations shall refer to U. S. Geological Survey Datum or other Government precise level bench marks based on sea-level datum.

Culture Maps.

To be tracings from the original maps of surveys of new lines, without the contours, for adoption by the Board of Directors, and to be filed in the offices of the secretaries of the states and clerks of counties, when required by law.

Track Layouts.

Tracks in all cases to be represented by single lines, except on plans of 50-foot scale or larger; where it is necessary to show the rails, double lines may be used. Indicate each track on the interlocking plans by a double line.

Record Plans.

Masonry.

All masonry records to be drawn to such a scale as will show clearly all dimensions as built, elevations of foundations, neat lines, bridge seats, base of rail, surface of water and ground line. Length of piles or elevation of points and number driven.

Clearance to be shown when crossed by railroad, road or street. In all cases give quantities in final estimate, location and station numbers.

Certificate.

A certificate as to the correctness of all maps and profiles to be filed with the Interstate Commerce Commission shall be printed and executed on the first sheet of each series, and each of the other sheets of the same series shall be identified as a part thereof. The certificate on the first sheet of each series shall be placed as near the title as practicable and shall be in the following form:

State of............................
County of............................

I, the undersigned, officer of the............................ do hereby
(Name of Railway Co.)
certify that this is a correct ....in a series of..........
(Map or Profile)
sheets of said railway from survey station................. ....to
survey station ....State of
(Main Line, Division or Branch)
.... prepared from the records of said company.

....
Engineer.

Correct:

....
(Name of officer authorized to certify records.)

Subscribed and sworn to before me this....... ....day
of.......................................

....
Notary Public in and for the
County of ....
State of ....

My commission expires...........................

The identification on the other sheets of a series shall be of the following form and placed as near the title as practicable:

Sheet No. .... of .... of.................................
(Series) (Railway, main line or branch)
from survey station.....................to survey station....................
....
Engineer.

RIGHT-OF-WAY AND TRACK MAPS.

A right-of-way and track map shall be a true horizontal projection of the right-of-way, tracks and other structures platted continuously between district or terminal points.

For each series of right-of-way and track maps there shall be made a small skeleton index map on a scale of not less than ¼-inch equals one mile. Where practicable this index map may be placed on any vacant space of the first sheet of the series, and where made on a separate sheet it shall be 24 inches by 56 inches. This index map shall show by outline with file numbers therein the sheets of a series, the name of main line, division or branch line, the principal towns or cities, and the beginning and ending station numbers of series, and any other information proper to place thereon.

All right-of-way and track map sheets shall be numbered serially, beginning with Sheet 1. The sheets representing valuation sections shall form separate series, and the valuation sections shall be numbered serially with the letter "V" preceding the number. Index numbers shall be in the lower right-hand corner of the sheet and enclosed in plain, single line circle one inch in diameter. Valuation section numbers shall be in the upper half of the circle and sheet number below with a straight line between.

On all right-of-way and track map sheet references to all station maps shall be shown by outlining limits of station maps and giving the number of the station map sheets.

The file number shall also be placed on all map sheets in the lower left-hand corner.

Corrections should be made whenever any changes are made in any of the features shown thereon, and at stated periods a corrected copy sent to the proper office.

On track maps drawn to a scale of one inch equals 50 feet or less, tracks should be represented exclusively by double lines.

On track maps drawn to a scale of one inch equals 200 feet or more, tracks should be represented exclusively by single lines.

On track maps drawn to a scale of one inch equals 100 feet; (a) on maps representing preliminary studies and designs of proposed track layouts, tracks may be represented by single lines. Double lines should be used where considered necessary to show turnout details; (b) on maps representing completed work, station plats and permanent records, tracks should be represented by double lines.

STATION MAPS.

The station maps shall be supplemental to the right-of-way and track maps for terminals and other locations where the property is so extensive and complicated that it cannot be clearly shown thereon.

The station maps shall be made as prescribed above for the right-of-way and track maps.

When more than one sheet is required to show a station property, the plat shall be made upon "matched marked" sheets in such manner as to require the minimum number.

The station maps shall be given the same serial number preceded by the letter "S" as the sheets of the right-of-way and track maps which they supplement.

In case a right-of-way and track map sheet is supplemented by more than one station map, a subscript letter should be used after the number, e. g., S 32_a. etc., where land and track features are combined; S-L 32_a. etc., where land only is shown; and S-T 32_a. etc., where track features only are shown.

The purpose of the large scale station maps is to permit the showing of improvements in more detail than is practicable on the right-of-way and track map.

Where the station property to be mapped is extensive and complicated, it may be delineated on two separate maps.

(1) Shall show all data relating to ownership of lands.

(2) Shall show all tracks and structures and external land boundaries.

Where practicable, without sacrificing the clearness of the map, the two may be combined into one map, or one class of property may be shown on the right-of-way and track map and the other on the station map.

Tracks shall be represented on station maps either by center lines or by rail lines.

Arrangement of Data on Right-of-Way and Track Maps and Station Maps.

The general direction of the center line of track shall be as nearly as possible parallel to and half-way between the long sides of the sheets, so that the maximum space each side of the platted right-of-way lines may be available for showing adjacent topography and property lines and for making notes as to physical property. The maximum length of main roadway represented on any one sheet (between "match marks") shall be two miles, if scale is one inch equals 200 feet, or in proportion thereof if other scales are used.

On them shall be shown the following data:

(a) Boundary Lines of All Right-of-Way.

The term right-of-way as herein used includes all lands owned or used for purposes of a common carrier, no matter how acquired.

Show: Width of right-of-way, in figures, at each end of the sheet and at points where a change of widths occurs, with station and plus of such points; boundary lines and dimensions of each separate tract acquired; a schedule of deed, custodian's number, the name of the grantor and grantee, kind of instrument, date and book page where recorded. Each tract of land shall be given a serial number and listed serially in the schedule. The schedule shall also include references to leases to the company, franchises, ordinances, grants and all other methods of acquisition.

(b) Boundary Lines of Detached Lands.

Where same can be shown clearly. The term "detached lands" as herein used includes:

(1) Lands owned or used for purposes of a common carrier, but not adjoining or connecting with other lands of the company.

(2) Lands owned and not used for purposes of a common carrier, either adjoining or disconnected from other property owned by the company.

Show: Boundary lines and dimensions; distance and bearing from some point on the boundary lines to some established point or permanent land corner, where practicable, and separately on the schedule above, the lands not used for purposes of a common carrier.

(c) Intersecting Property Lines of Adjacent Land Owners.

Where the information is in possession of the company or can readily be obtained, show: The property lines of adjacent land owners, the station and plus of important intersections of property lines with center line of railway or other railway base line, and the names of the owners of the land adjacent to the right-of-way.

(d) Intersecting Divisional Land Lines.

Show: Section, township, county, state, city, town, village or other governmental lines, with names or designations; the width and names of streets and highways which intersect the right-of-way, and the station and plus at all such points of crossings or intersections with center lines of railway or other railway base line.

(e) Division and Sub-Division of Lands Beyond the Limits of the Right-of-Way.

Where the information is in possession of the company, show: The section and quarter-section lines for a maximum distance of one mile on each side of the center line or base line of railway where the land has been sub-divided into townships and sections; such data as to divisions, tracts, streets, alleys, blocks and lots, where the land has been divided in some other way than by sections; the distance, where known, from railway base line to permanent land corners or monuments, and the base line from which the railway's lands were located (center line of first, second, third or fourth main track or other base line).

(f) Alinement of Tracks.

Show: The center line of each main and side track and distances between them; the length, in figures, of all sidetracks from point of switch to point of switch, or point of switch to end of track; all street car lines and other railways, crossed (with angle of crossing) or connecting, and state if crossing is over or under grade, and give name of owner of such tracks; survey station number at even 1,000 scale-feet intervals, and station and plus at points of all main line switches, at points of curves and tangents and at beginning and ending points on each sheet; the degree and central angle of curves, and joint tracks and ownership thereof. On right-of-way and track maps inside the limits covered by the station maps it will not be necessary to show the sidetracks when to do so will obscure more important data.

(g) Improvements.

Show: Station and office buildings, shops, engine houses, turntables, fuel stations, water stations, etc. (owned by the company), in general outline, where it can be done clearly. Also indicate conventionally: Bridges, trestles, culverts, tunnels, retaining walls, stock guards, mileposts, signals of all kinds and signal bridges and ground masts, wire lines of all kinds and supports, fences by note only, and other principal railway structures owned by the company, with general data as to dimensions, and character thereof and location with reference to main or side tracks, and where practicable, pipe lines, sewers, underground conduits, paving, curbing or similar works located on right-of-way or adjoining and owned by the company in whole or in part. Give station and plus to all important structures which are outlined above.

(h) Topographical Features.

Show: Rivers and creeks, water courses, with arrows showing direction of current, highway crossings, etc. Give names, where known, and when highway crossings are over or under grade, so state.

Show all other surface and subsurface improvements not hereinbefore noted, as far as may be practicable.

PROFILES.

The profile shall be a vertical, sectional view on center line of track (or other railway base line) on an exaggerated vertical scale, and shall show the features of the railway track substructure and superstructure, which can best be indicated in vertical projection; also such other detail information as is hereinafter more fully set forth. The elevation of surface of water in rivers and streams and flood lines shall be shown also, where it is possible to do so. All elevations to refer to U. S. Geological Survey Datum or other Government precise level bench marks based on sea-level datum.

Profiles shall be made and numbered serially, beginning with sheet No. 1 so that any serially numbered sheet shall cover the same portion of the railway as the like serially numbered sheet or sheets of the right-of-way and track maps. The sheets representing valuation sections shall form separate series, and valuation sections shall be numbered serially with the letter "V" preceding the number, and the letter "P" shall precede the serial number or numbers of the sheets. Index numbers shall be in the lower right-hand corner of the sheet and enclosed in a plain, single line circle one inch in diameter.

Valuation section numbers shall be in the upper half of the circle and sheet number or numbers below with a straight line between.

The file number shall also be placed on all profile sheets in the lower left-hand corner.

Platting shall be done as specified for right-of-way and track maps.

The 2½-inch space immediately above the lower border line shall be used for track alinement and topographic data. The remaining 7½-inch space shall be used for platting in such a way as to most economically utilize the space.

The following data shall be placed on all profiles:

(a) Roadway.

Show: The vertical projection of the original ground surface on center line of railway; present grade line (top of the roadbed subgrade); rates of grade; elevations (sea-level datum) at all points of change of grade, at end of sheets and where profile is "broken," at 50-foot (scale) intervals; and the station and plus to points of change of grade and station numbers at each 1,000 foot (scale) interval near lower border of sheet.

(b) Structures.

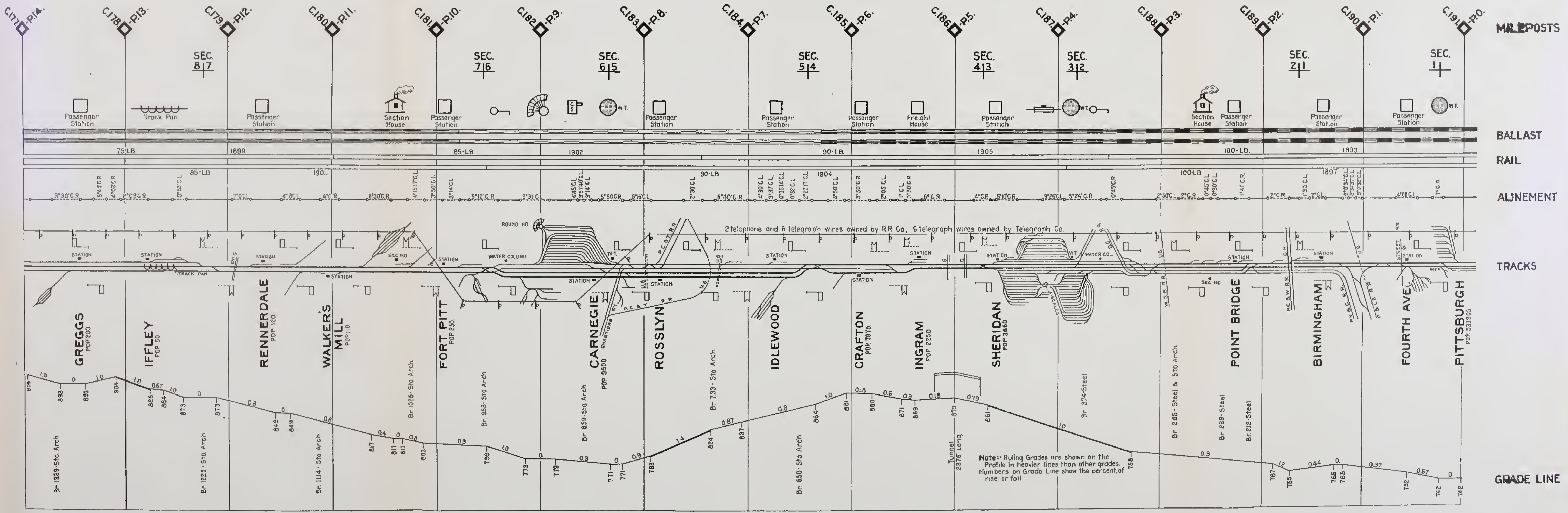
Show: Bridges, trestles, culverts, retaining walls, tunnels and other roadbed structures in vertical projection, stating the kind and general dimensions by figures; average depth of penetration of piling in each bent of trestles, or under other structures, by vertical projection; character of, and depth of foundation bed of masonry structures by vertical projection; reference to railway file numbers of the detail standard or special plans by which the structures were built; existing mileposts and the station and plus of each of the above-indicated improvements.

(c) Quantities.

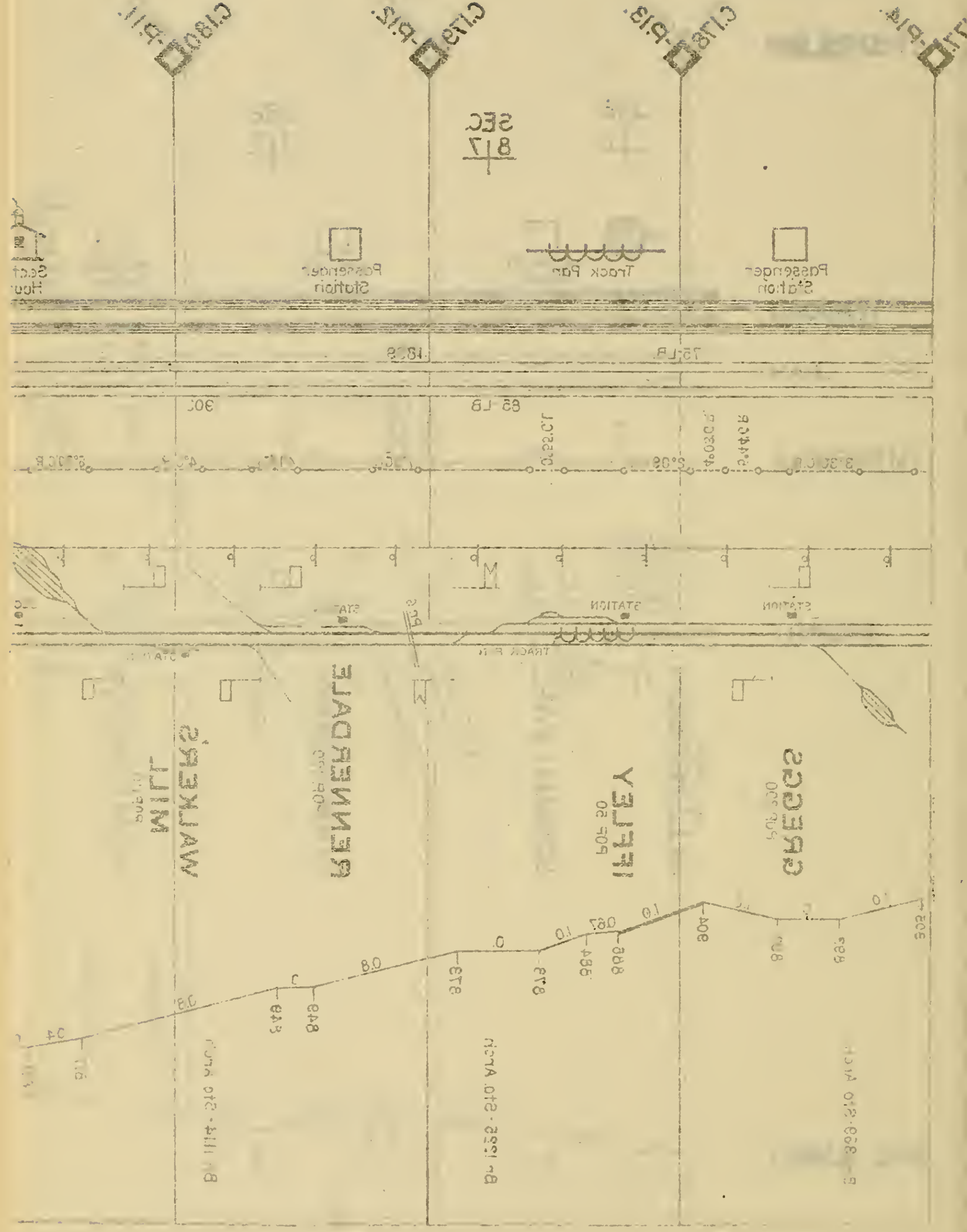
Profiles of railways built after February 1, 1914, shall show for each mile a summary of construction quantities to subgrade, including roadway, bridges and culverts. Profile of railways built before February 1, 1914, may show, at the option of the company, similar quantities in the same summary form.

The summary of quantities shall be in detail, according to the standard classification of units used by the company.

TRACK CHART



Note:- Ruling Grades are shown on the Profile in heavier lines than other grades. Numbers on Grade Line show the percent of rise or fall

C180-P11
C179-P12
C178-P13
P14
SEC
8 17
Sect Hou
Passenger Station
Track Pan
Passenger Station
1828
75 LB.
90L
85 LB
STATION
STATION
TRACK PAN
WALKERS' MILL
RENNERDALE
IFFLEY
POP 50
GREGGS
0.3
0.8
0.67
1.0
843
848
873
884
888
906
B-1114-Sto Arch
B-1295-Sto Arch
B-929-Sto Arch

(d) Alinement and Track.

Show: On the lower 2½x55-inch space of the profile sheet, the center line of each main track, developed into straight line or lines, with alinement notes of curves stated in figures; the station and plus at points of curves and tangents, and other data, such as passing tracks, depot buildings, water and fuel stations, highway crossings, railway crossings and important water courses that will assist in interpreting the profile. For platting transversely, a scale of one inch equals 200 feet shall be used.

[4] TRACK CHART.

A Track Chart showing complete information respecting the grade, alinement and other physical features of a railway is necessary, and the "Track Chart," Form 1121, is recommended.

[5] PROGRESS PROFILE.

A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railway is necessary, and the standard "Progress Profile," Form 1122, is recommended.

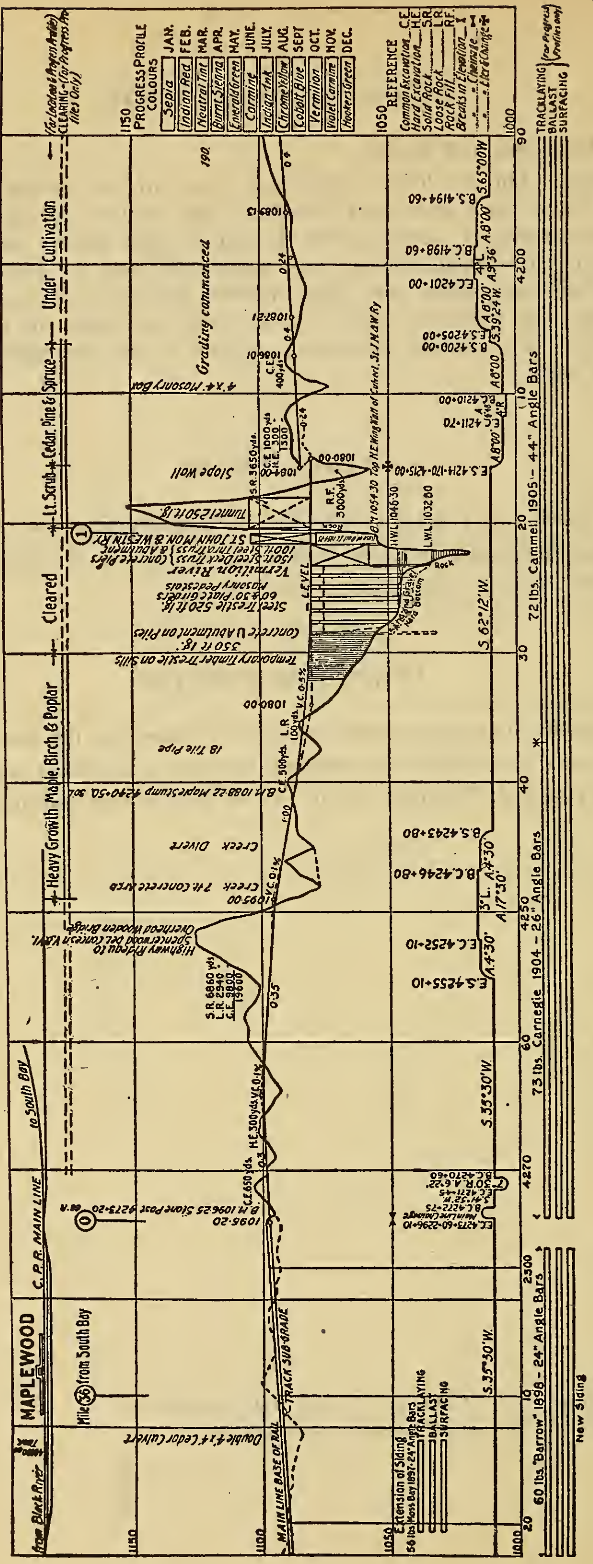
---

[4] Adopted, Vol. 8, 1907, pp. 111, 112, 114, 116-120, 132.

[5] Adopted, Vol. 7, 1906, pp. 278, 280, 328, 329.

Form 1122

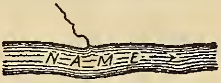
PROGRESS PROFILE.



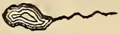
[6] CONVENTIONAL SIGNS FOR USE ON RAILWAY PROFILES, RIGHT-OF-WAY AND TRACK MAPS.

HYDROGRAPHY.

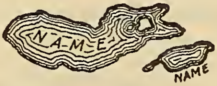
Stream



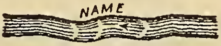
Springs and Sinks



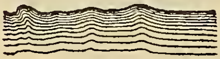
Lakes and Ponds



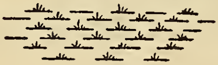
Falls and Rapids



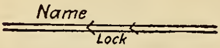
Water Line



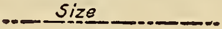
Marsh



Canals

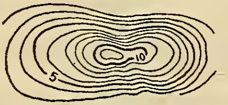


Ditches

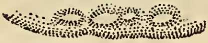


RELIEF.

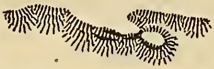
Contour System



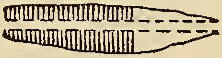
Sand



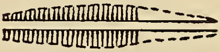
Cliffs



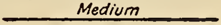
Cut



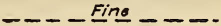
Embankment



Top of Slope



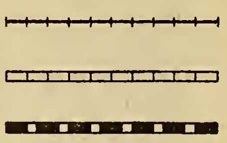
Bottom of Slope



---

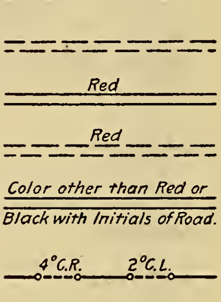
[6] Adopted, Vol. 15, 1914, pp. 930-940, 1160; Vol. 16, 1915, pp. 789, 1086, 1087.

* RAILWAYS (TOPOGRAPHICAL MAPS.)



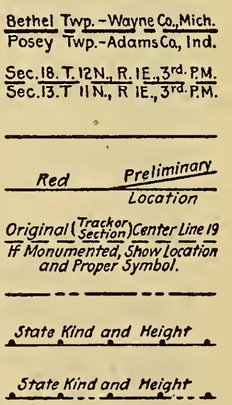
Steam	
Electric	
Street Railways	

* RAILWAY TRACKS (TRACK MAPS.)



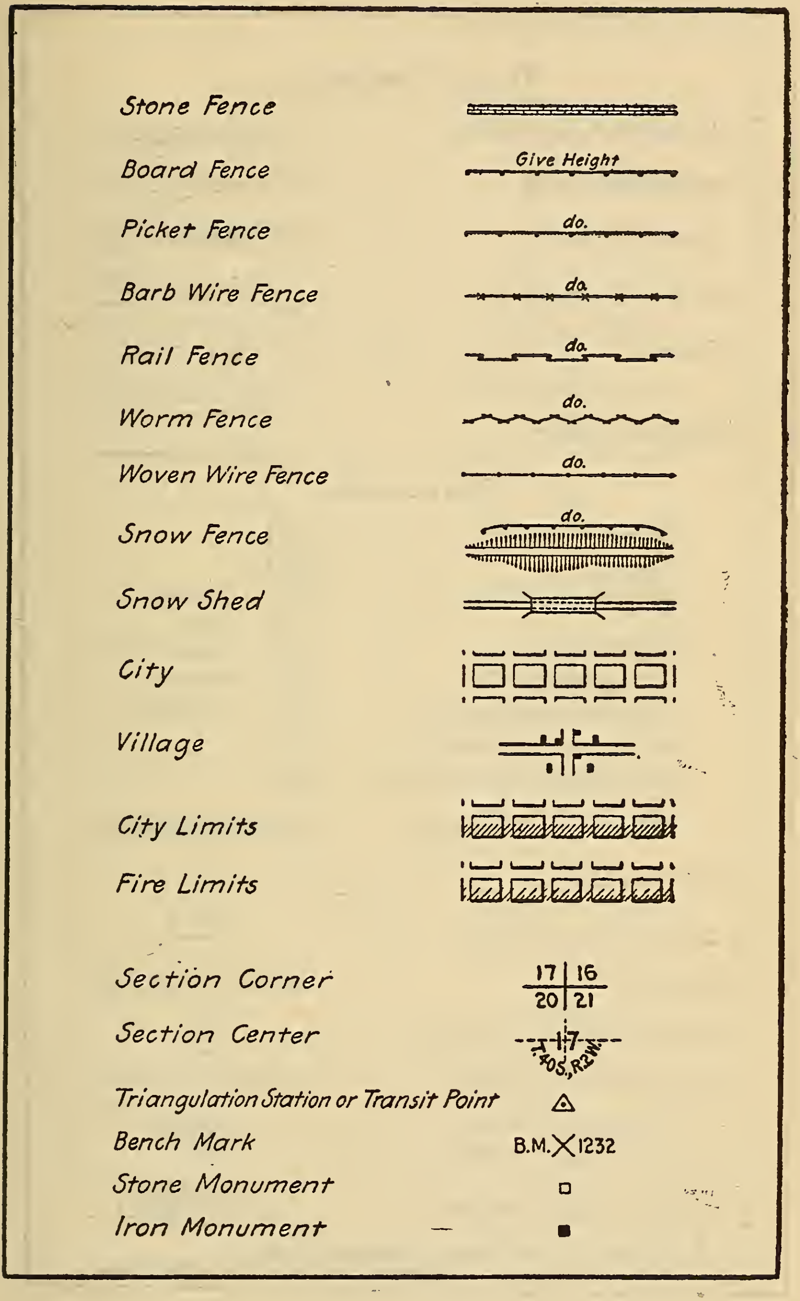
Railway Track or Old Track to Remain	
Old Track to be Taken up	
Proposed Tracks	*Red*
Proposed (Future) Tracks	*Red*
Foreign Tracks	*Color other than Red or* *Black with Initials of Road.*
Alinement { *4° Curve to Right* *2° " " Left* }	*4° C.R.* *2° C.L.*

BOUNDARY AND SURVEY LINES.

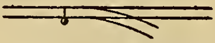
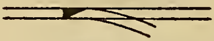
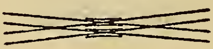
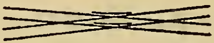
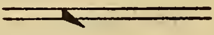
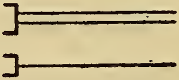


{ *Political Divisions; State, County* *or Township Lines.*	Bethel Twp.-Wayne Co., Mich. Posey Twp.-Adams Co., Ind.
{ *Government Surveys, Base, Meridian,* *Township, Section or Harbor Line*	Sec. 18. T. 12 N., R. 1 E., 3rd. P.M. Sec. 13. T 11 N., R 1 E., 3rd. P.M.
Street, Block or other Property Line	
Survey Lines	*Red* *Preliminary* *Location*
Center Lines	*Original (Track or Section) Center Line 19* *If Monumented, Show Location and Proper Symbol.*
Company Property Boundary Line	
Fence (on Street Line)	*State Kind and Height*
Fence (on Company Property Line)	*State Kind and Height*

* *For Railway Track and Yard Studies Use Single or Double Lines.*

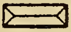
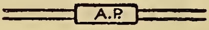
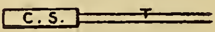
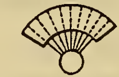
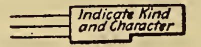

Stone Fence
Board Fence
Give Height
Picket Fence
do.
Barb Wire Fence
do.
Rail Fence
do.
Worm Fence
do.
Woven Wire Fence
do.
Snow Fence
do.
Snow Shed
City
Village
City Limits
Fire Limits
Section Corner
17 16
20 21
Section Center
17
T.40S., R2W.
Triangulation Station or Transit Point
Bench Mark
B.M. X 1232
Stone Monument
Iron Monument

TRACK FIXTURES.

Turnout and Switch-Stand	
Interlocked Switch	
Double Slip Switch	
Single Slip Switch	
Derail	
Bumping Post	

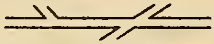
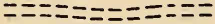
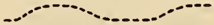
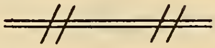
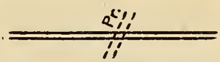
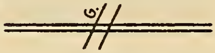
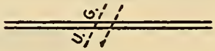
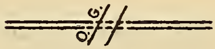
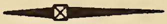
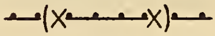
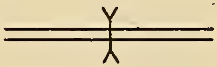
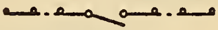
* BUILDINGS.

Stone	S	
Frame	F	
Brick	B	*Indicate Use and Number of Stories.*
Concrete	C	
Corrugated Iron	Cor. I.	
Brick Passenger Station	B.P.	
Electrical Sub-Station	S.S.	
Lightning Arrester House	L.A.	
Platform or Driveway	*Indicate Kind and Character*	

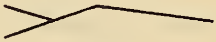
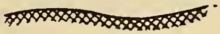
Turntable	
Interlocking Tower	
Ash Pit	
Coal Chute (Mechanical)	
Coal Chute (Trestle)	
Circular Engine House	
Square Engine House	 *Indicate Kind and Character*

* *Indicate Type and Construction by Combination of Letters, as: F.F.-Freight Frame Station, B.F.-Brick Freight Station.*

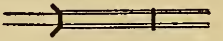
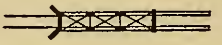
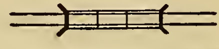
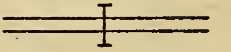
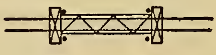
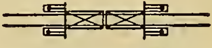
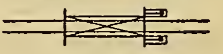
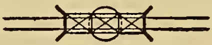
HIGHWAYS AND CROSSINGS.

Public and Main Roads	
Private and Secondary Roads	
Trails	
Street and Public Road Crossings	
Private Road Crossing	
Road Crossing at Grade	
" " under "	
" " overhead	
Crossing Gate	
Turnstile	
Cattle Guard	
Farm Gate	

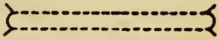
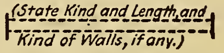
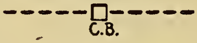
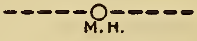
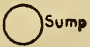
MINES.

Tunnel	
Shaft	
Test Opening	
Coal Outcrop	
Mine in Operation	

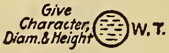
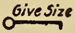
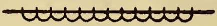
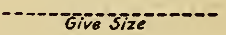
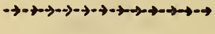
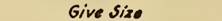
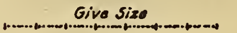
BRIDGES.

Girder	
Truss	
Trestle	
Signal Bridge	
Lift Span	
Bascule, Double Leaf	
Bascule, Single Leaf	
Draw Span	

CULVERTS, SEWERS, ETC.

Masonry Arch or Flat Top Culvert	
Pipe or Wood Box Culvert or Drain	
Catch Basin	
Manhole	
Sump	

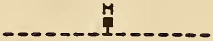
WATER SUPPLY AND PIPE LINES.

Water Tank	
Water Column	
Track Pan	
Company Water Pipe	
Other Water Pipe	
Steam or Gas	
Compressed Air	

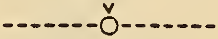
WATER SUPPLY AND PIPE LINES.

(CONTINUED.)

Fire Hydrant

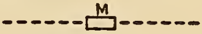


Valve

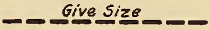


Riser

Meter

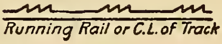


Sewer or Drain

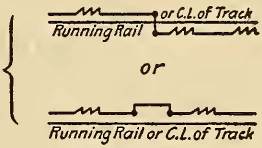


ELECTRIFIED LINES.

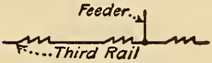
Third Rail



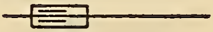
Jumpers.



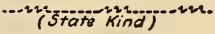
Feeder



Switch



Overhead Rail or Wire



Rail.

Give Weight in Lbs. per Yard.

Ballast.

Earth

Sand

Cinders

Gran. Slag

Screenings

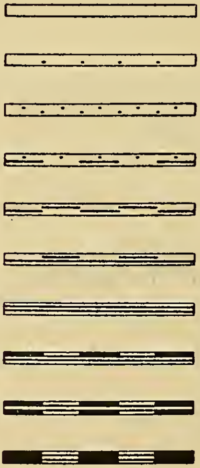
Burnt Clay

Chats

Gravel

Slag

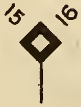
Broken Stone



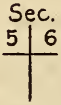
Vol. 16, pp. 789. 1086. 1087.

SIGNS AND SIGNALS.

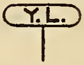
Mile Post



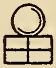
Section Post



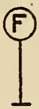
Yard Limits



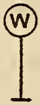
Highway Crossing Bell



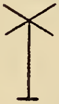
Flanger Sign



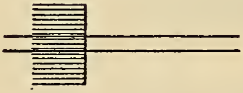
Whistle Post



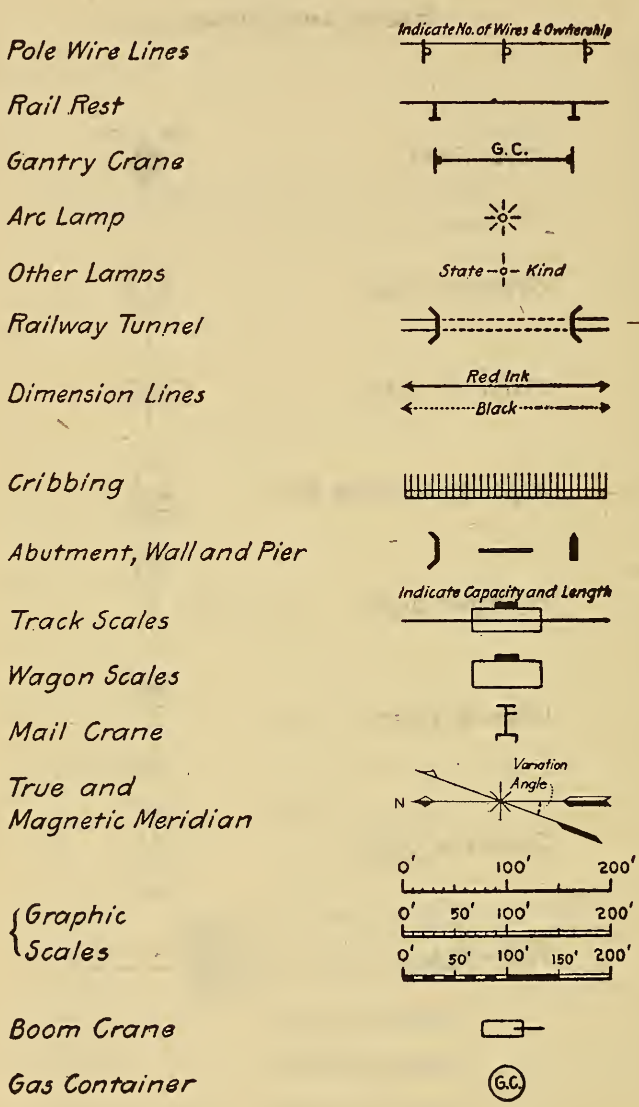
Crossing Sign

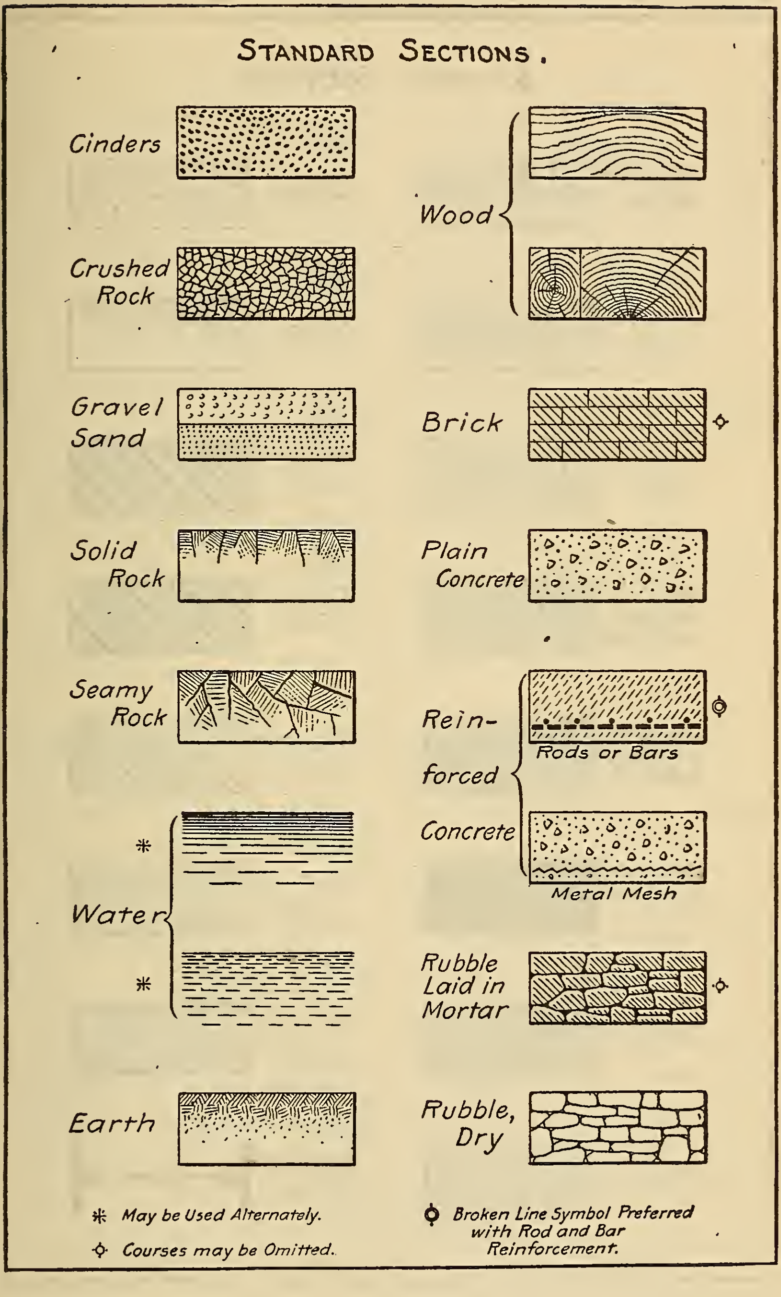


Tell-Tale

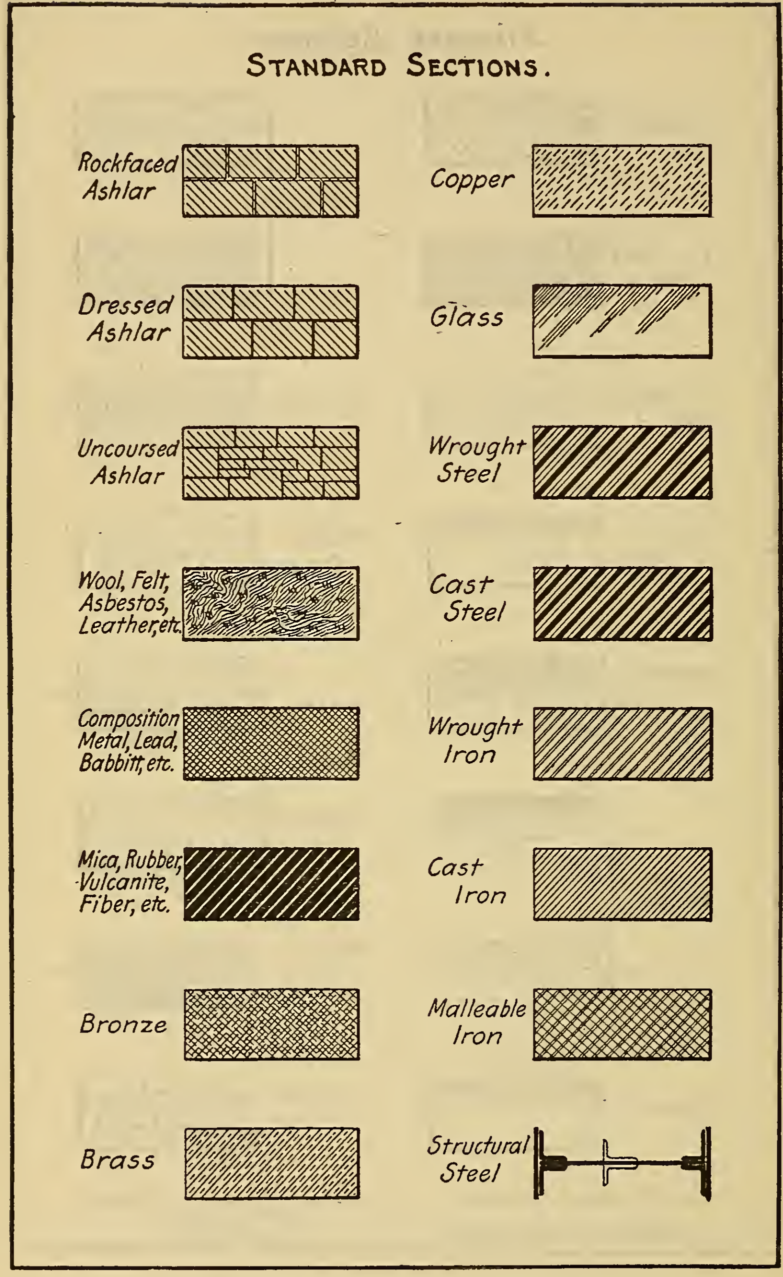


MISCELLANEOUS.

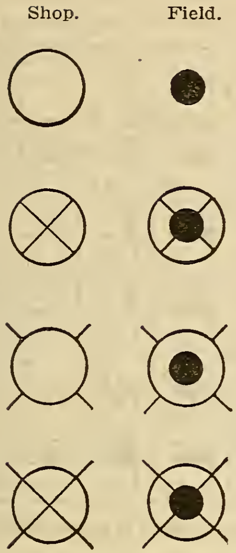




STANDARD SECTIONS.


STANDARD SECTIONS.
Rockfaced Ashlar
Copper
Dressed Ashlar
Glass
Uncoursed Ashlar
Wrought Steel
Wool, Felt, Asbestos, Leather, etc.
Cast Steel
Composition Metal, Lead, Babbitt, etc.
Wrought Iron
Mica, Rubber, Vulcanite, Fiber, etc.
Cast Iron
Bronze
Malleable Iron
Brass
Structural Steel

A—BRIDGE RIVETS.

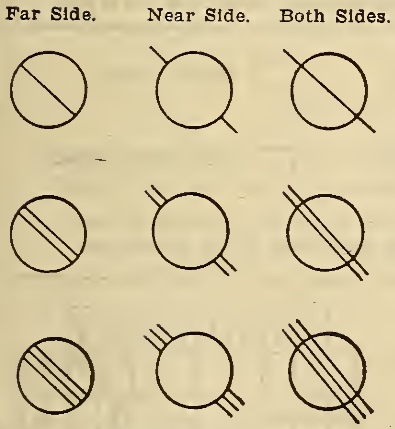


Two Full Heads.

Countersunk and chipped, far side.

Countersunk and chipped, near side.

Countersunk and chipped, both sides.



Countersunk and not chipped.

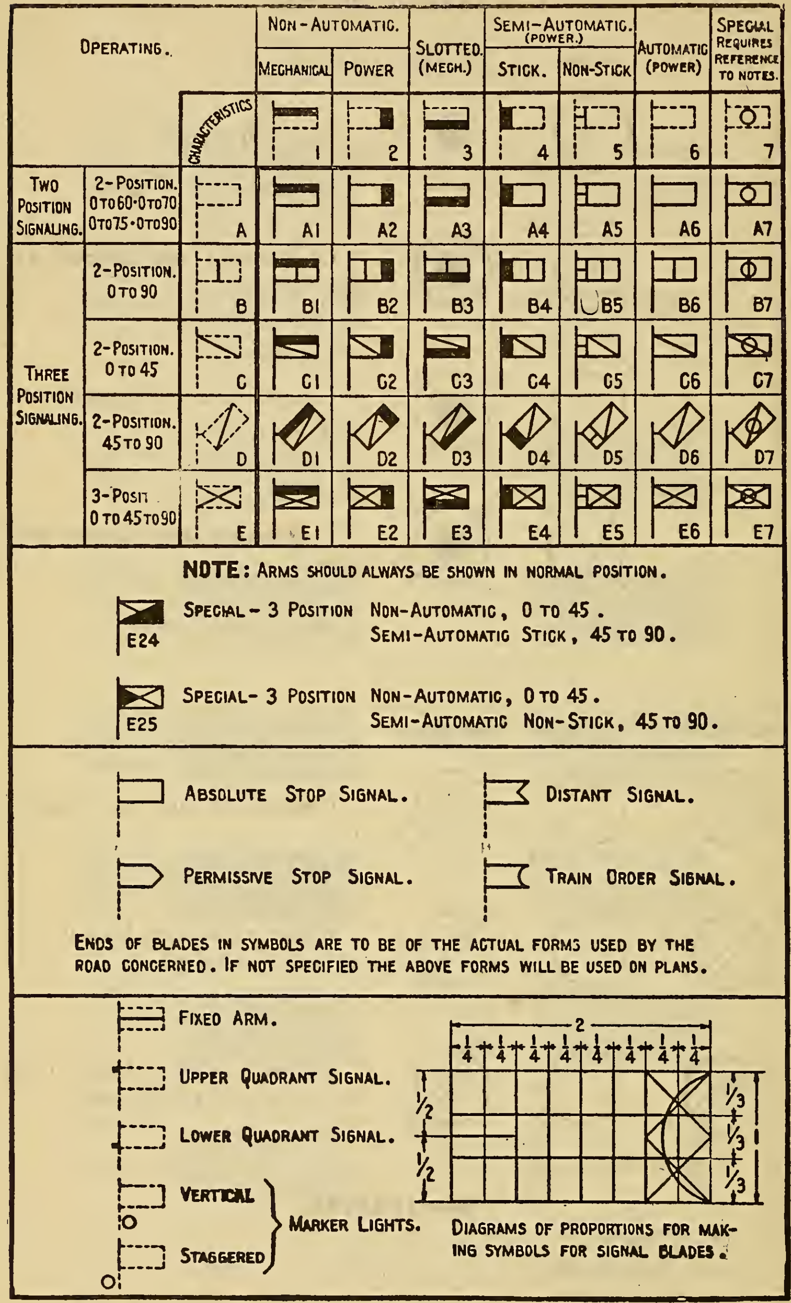
Flattened to ¼-in. high for ½-in. and ⅝-in. rivets.

Flattened to ⅜-in. high for ¾-in., ⅞-in. and 1-in. rivets.

B—STRESSES.

+ Tension.
— Compression.

[7] CONVENTIONAL SIGNS FOR SIGNALS AND INTERLOCKING.



Operating.		Characteristics	Non-Automatic. Mechanical	Non-Automatic. Power	Slotted. (Mech.)	Semi-Automatic. (Power.) Stick.	Semi-Automatic. (Power.) Non-Stick	Automatic (Power)	Special Requires Reference to Notes.
			1	2	3	4	5	6	7
Two Position Signaling.	2-Position. 0 to 60·0 to 70 0 to 75·0 to 90	A	A1	A2	A3	A4	A5	A6	A7
Three Position Signaling.	2-Position. 0 to 90	B	B1	B2	B3	B4	B5	B6	B7
	2-Position. 0 to 45	C	C1	C2	C3	C4	C5	C6	C7
	2-Position. 45 to 90	D	D1	D2	D3	D4	D5	D6	D7
	3-Posit. 0 to 45 to 90	E	E1	E2	E3	E4	E5	E6	E7

NOTE: Arms should always be shown in normal position.

E24 Special – 3 Position Non-Automatic, 0 to 45.
Semi-Automatic Stick, 45 to 90.

E25 Special – 3 Position Non-Automatic, 0 to 45.
Semi-Automatic Non-Stick, 45 to 90.

Absolute Stop Signal.

Distant Signal.

Permissive Stop Signal.

Train Order Signal.

Ends of blades in symbols are to be of the actual forms used by the road concerned. If not specified the above forms will be used on plans.

Fixed Arm.

Upper Quadrant Signal.

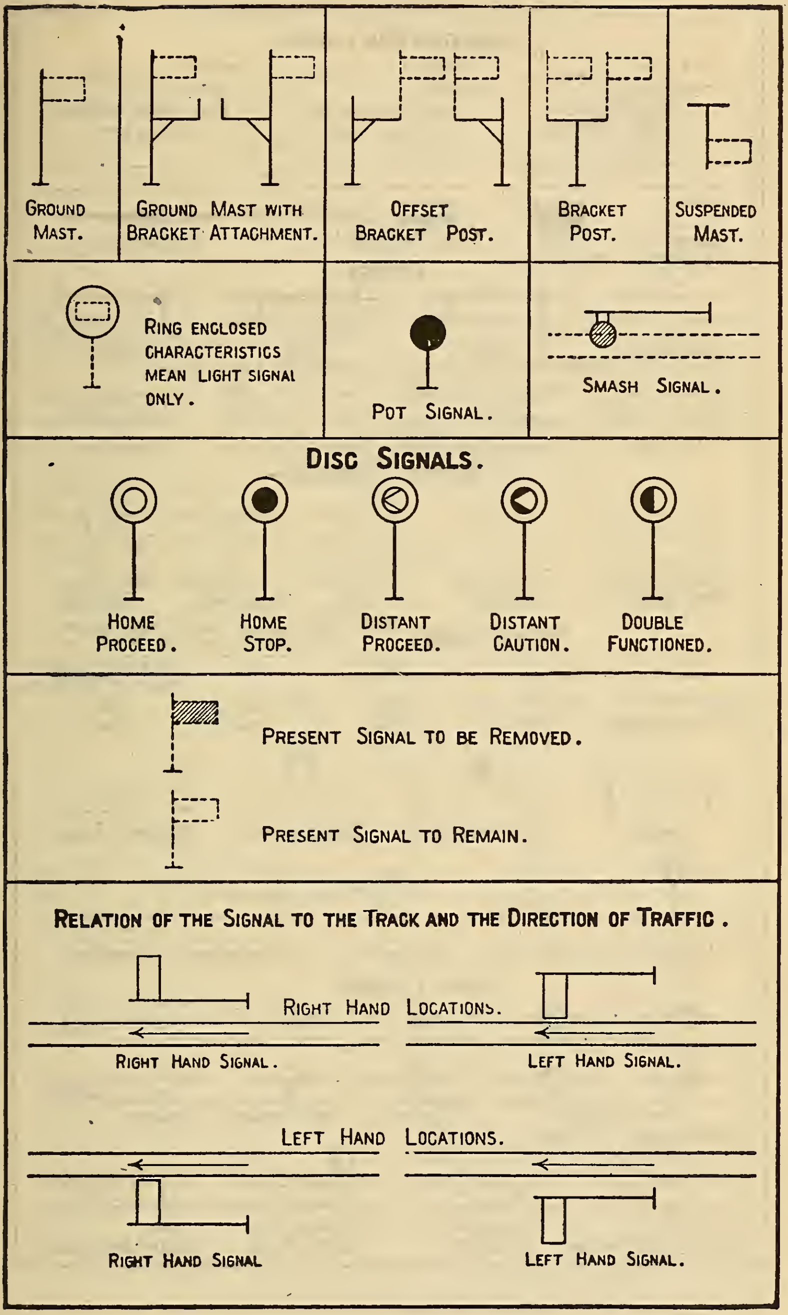
Lower Quadrant Signal.

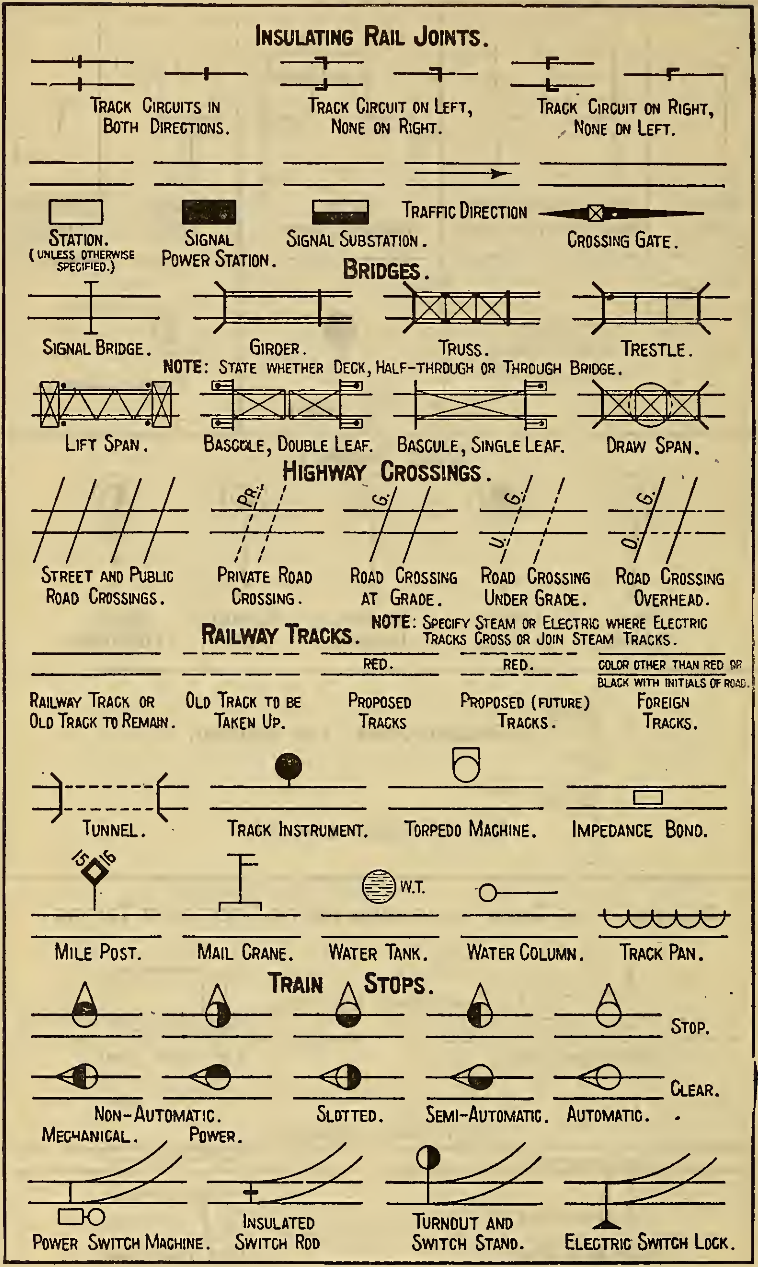
Vertical } Marker Lights.
Staggered }

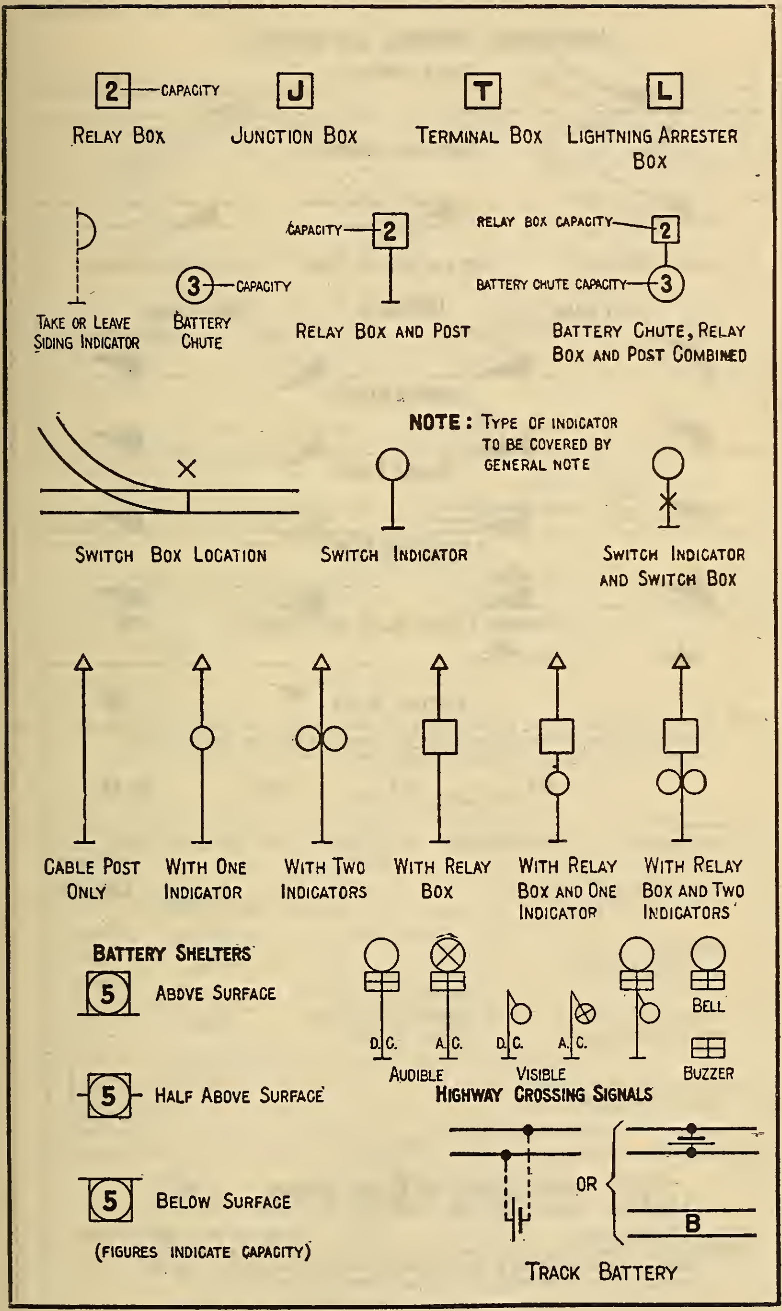
Diagrams of proportions for making symbols for signal blades.

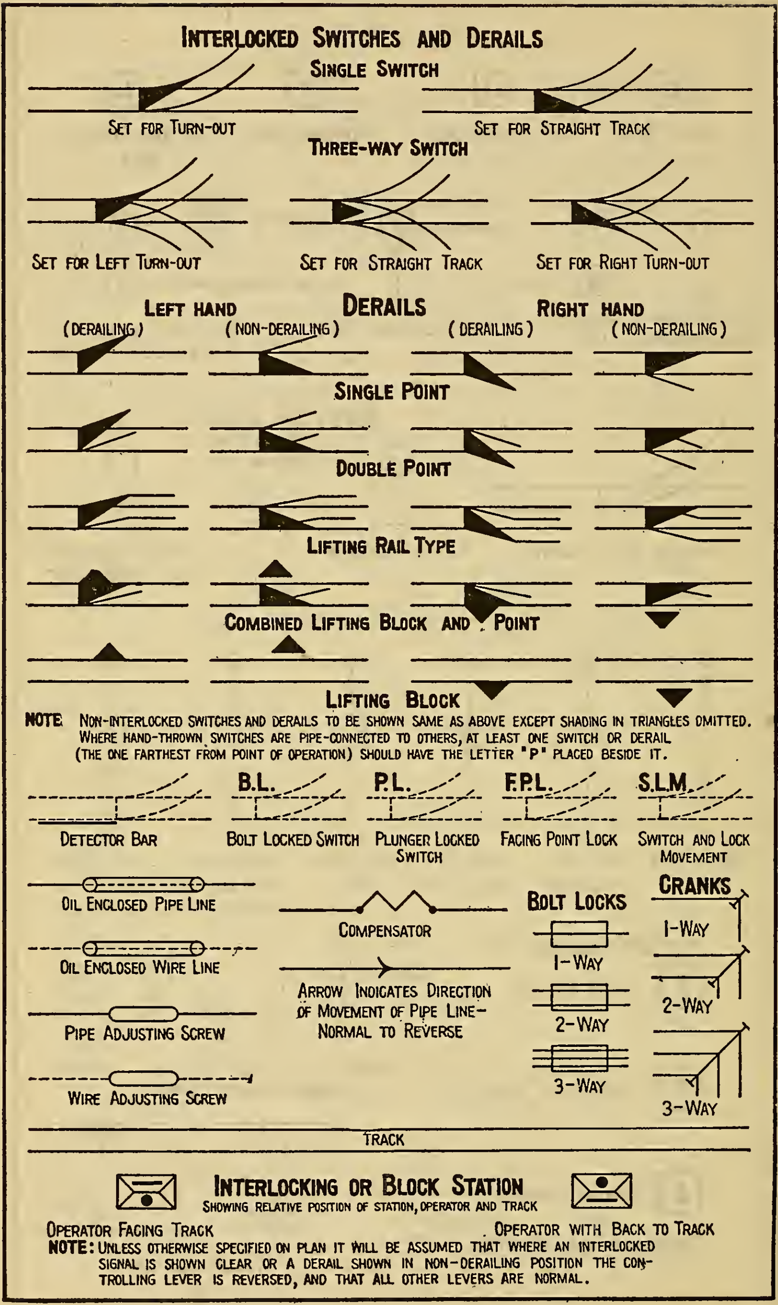
---

[7] Adopted, Vol. 7, 1906, pp. 515-521, 548; Vol. 15, 1914, pp. 81-92, 1009.


Ground Mast.
Ground Mast with Bracket Attachment.
Offset Bracket Post.
Bracket Post.
Suspended Mast.
Ring enclosed characteristics mean light signal only.
Pot Signal.
Smash Signal.
Disc Signals.
Home Proceed.
Home Stop.
Distant Proceed.
Distant Caution.
Double Functioned.
Present Signal to be Removed.
Present Signal to Remain.
Relation of the Signal to the Track and the Direction of Traffic.
Right Hand Locations.
Right Hand Signal.
Left Hand Signal.
Left Hand Locations.
Right Hand Signal
Left Hand Signal.


INSULATING RAIL JOINTS.
TRACK CIRCUITS IN BOTH DIRECTIONS.
TRACK CIRCUIT ON LEFT, NONE ON RIGHT.
TRACK CIRCUIT ON RIGHT, NONE ON LEFT.
TRAFFIC DIRECTION
STATION. (UNLESS OTHERWISE SPECIFIED.)
SIGNAL POWER STATION.
SIGNAL SUBSTATION.
CROSSING GATE.
BRIDGES.
SIGNAL BRIDGE.
GIRDER.
TRUSS.
TRESTLE.
NOTE: STATE WHETHER DECK, HALF-THROUGH OR THROUGH BRIDGE.
LIFT SPAN.
BASCULE, DOUBLE LEAF.
BASCULE, SINGLE LEAF.
DRAW SPAN.
HIGHWAY CROSSINGS.
P.R.
G.
G.
U.
G.
O.
STREET AND PUBLIC ROAD CROSSINGS.
PRIVATE ROAD CROSSING.
ROAD CROSSING AT GRADE.
ROAD CROSSING UNDER GRADE.
ROAD CROSSING OVERHEAD.
RAILWAY TRACKS.
NOTE: SPECIFY STEAM OR ELECTRIC WHERE ELECTRIC TRACKS CROSS OR JOIN STEAM TRACKS.
RED.
RED.
COLOR OTHER THAN RED OR BLACK WITH INITIALS OF ROAD.
RAILWAY TRACK OR OLD TRACK TO REMAIN.
OLD TRACK TO BE TAKEN UP.
PROPOSED TRACKS
PROPOSED (FUTURE) TRACKS.
FOREIGN TRACKS.
TUNNEL.
TRACK INSTRUMENT.
TORPEDO MACHINE.
IMPEDANCE BOND.
15
16
W.T.
MILE POST.
MAIL CRANE.
WATER TANK.
WATER COLUMN.
TRACK PAN.
TRAIN STOPS.
STOP.
CLEAR.
NON-AUTOMATIC.
MECHANICAL.
POWER.
SLOTTED.
SEMI-AUTOMATIC.
AUTOMATIC.
POWER SWITCH MACHINE.
INSULATED SWITCH ROD
TURNOUT AND SWITCH STAND.
ELECTRIC SWITCH LOCK.


2
CAPACITY
RELAY BOX
J
JUNCTION BOX
T
TERMINAL BOX
L
LIGHTNING ARRESTER BOX
TAKE OR LEAVE SIDING INDICATOR
3
CAPACITY
BATTERY CHUTE
CAPACITY
2
RELAY BOX AND POST
RELAY BOX CAPACITY
2
BATTERY CHUTE CAPACITY
3
BATTERY CHUTE, RELAY BOX AND POST COMBINED
SWITCH BOX LOCATION
NOTE: TYPE OF INDICATOR TO BE COVERED BY GENERAL NOTE
SWITCH INDICATOR
SWITCH INDICATOR AND SWITCH BOX
CABLE POST ONLY
WITH ONE INDICATOR
WITH TWO INDICATORS
WITH RELAY BOX
WITH RELAY BOX AND ONE INDICATOR
WITH RELAY BOX AND TWO INDICATORS
BATTERY SHELTERS
5
ABOVE SURFACE
5
HALF ABOVE SURFACE
5
BELOW SURFACE
(FIGURES INDICATE CAPACITY)
D.C.
A.C.
AUDIBLE
D.C.
A.C.
VISIBLE
BELL
BUZZER
HIGHWAY CROSSING SIGNALS
OR
B
TRACK BATTERY



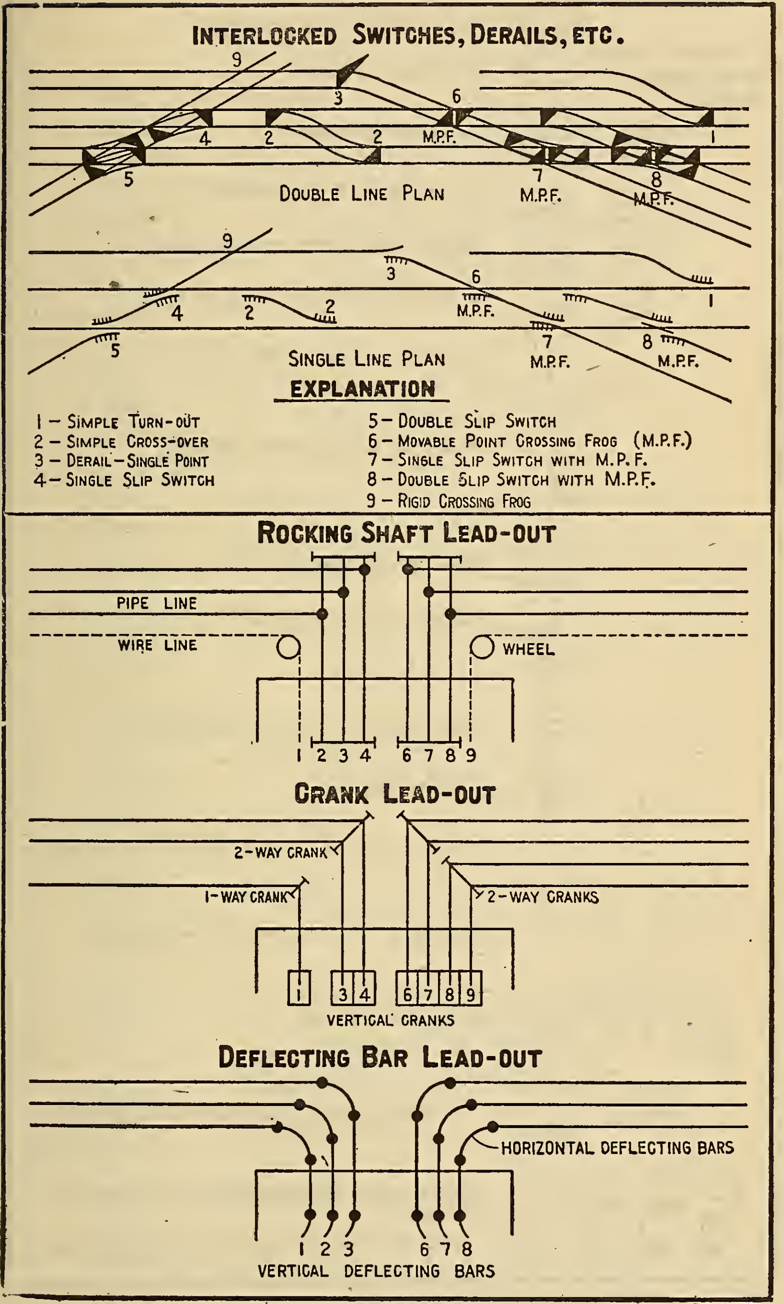
INTERLOCKED SWITCHES AND DERAILS

NOTE: NON-INTERLOCKED SWITCHES AND DERAILS TO BE SHOWN SAME AS ABOVE EXCEPT SHADING IN TRIANGLES OMITTED. WHERE HAND-THROWN SWITCHES ARE PIPE-CONNECTED TO OTHERS, AT LEAST ONE SWITCH OR DERAIL (THE ONE FARTHEST FROM POINT OF OPERATION) SHOULD HAVE THE LETTER "P" PLACED BESIDE IT.

INTERLOCKING OR BLOCK STATION

SHOWING RELATIVE POSITION OF STATION, OPERATOR AND TRACK

NOTE: UNLESS OTHERWISE SPECIFIED ON PLAN IT WILL BE ASSUMED THAT WHERE AN INTERLOCKED SIGNAL IS SHOWN CLEAR OR A DERAIL SHOWN IN NON-DERAILING POSITION THE CONTROLLING LEVER IS REVERSED, AND THAT ALL OTHER LEVERS ARE NORMAL.



INTERLOCKED SWITCHES, DERAILS, ETC.

EXPLANATION

1 – Simple Turn-out
2 – Simple Cross-over
3 – Derail – Single Point
4 – Single Slip Switch
5 – Double Slip Switch
6 – Movable Point Crossing Frog (M.P.F.)
7 – Single Slip Switch with M.P.F.
8 – Double Slip Switch with M.P.F.
9 – Rigid Crossing Frog

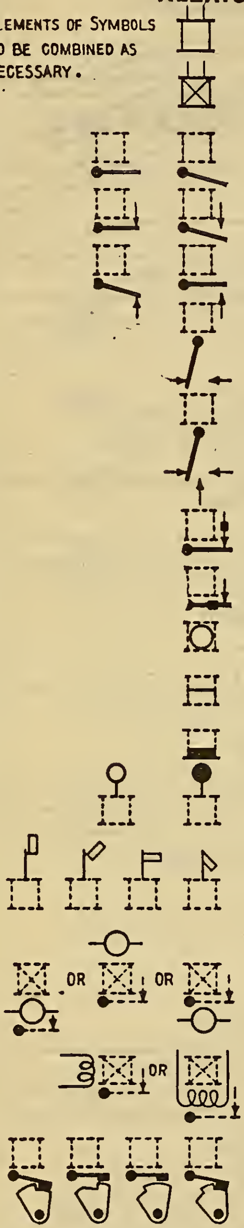
ROCKING SHAFT LEAD-OUT

CRANK LEAD-OUT

DEFLECTING BAR LEAD-OUT

RELAYS, INDICATORS AND LOCKS.

ELEMENTS OF SYMBOLS TO BE COMBINED AS NECESSARY.



D. C. ELECTRO MAGNET.

A. C. ELECTRO MAGNET.

COIL ENERGIZED OR DE-ENERGIZED.

NEUTRAL FRONT CONTACT – CLOSED OR OPEN.

NEUTRAL BACK CONTACT – CLOSED OR OPEN.

POLARIZED ARMATURE – WITH CONTACTS.

3-POSITION ARMATURE – WITH CONTACTS.

HIGH CURRENT CONTACT.

MAGNETIC BLOW-OUT CONTACT.

BELL ATTACHMENT.

DOUBLE WINDING – SPECIFY IF DIFFERENTIAL.

SLOW ACTING.

DISC TYPE INDICATOR. ○ = DISC INVISIBLE. ● = DISC VISIBLE.

SEMAPHORE TYPE INDICATOR. ⚐ = 3-POSITION.

WIRE WOUND ROTOR.

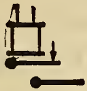
STATIONARY WINDING. ☒ = HIGH VOLTAGE WINDING.

ELECTRIC LOCK – SHOW SEGMENTS FOR LEVER IN NORMAL POSITION.

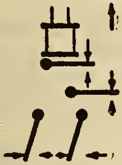
(SEE NEXT PAGE FOR EXAMPLES OF COMBINATIONS.)

RELAYS, INDICATORS AND LOCKS.

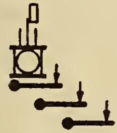
EXAMPLES OF COMBINATIONS.



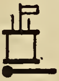
D.C. RELAY — NEUTRAL — ENERGIZED —
ONE INDEPENDENT FRONT CONTACT CLOSED —
ONE INDEPENDENT BACK CONTACT OPEN.



D.C. RELAY — POLARIZED — ENERGIZED —
TWO COMBINATION FRONT AND BACK NEUTRAL CONTACTS —
TWO POLARIZED CONTACTS CLOSED —
TWO POLARIZED CONTACTS OPEN.

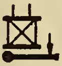


D.C. INDICATOR — SEMAPHORE TYPE — ENERGIZED —
THREE FRONT CONTACTS CLOSED —
BELL ATTACHMENT.

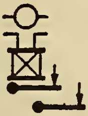


D.C. INDICATOR — SEMAPHORE TYPE — ARM HORIZONTAL —
ENERGIZED — WITHOUT CONTACTS.

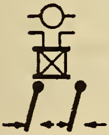
NOTE: INDICATORS (OR REPEATERS) WITHOUT CONTACTS SHOULD BE SHOWN WITH ARMATURES TO INDICATE WHETHER ENERGIZED OR DE-ENERGIZED.



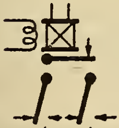
A.C. RELAY — ONE ENERGIZING CIRCUIT TYPE (SINGLE PHASE)
ENERGIZED — ONE FRONT CONTACT.



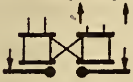
A.C. RELAY — TWO ENERGIZING CIRCUIT TYPE — ENERGIZED —
WIRE WOUND ROTOR —
TWO NEUTRAL FRONT CONTACTS.



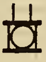
A.C. RELAY — TWO ENERGIZING CIRCUIT TYPE — ENERGIZED —
WIRE WOUND ROTOR —
TWO POLARIZED CONTACTS.



A.C RELAY — TWO ENERGIZING CIRCUIT TYPE — ENERGIZED —
STATIONARY WINDINGS —
ONE NEUTRAL FRONT CONTACT —
TWO 3-POSITION CONTACTS.



D.C. INTERLOCKED RELAY.



D.C. ELECTRIC BELL.

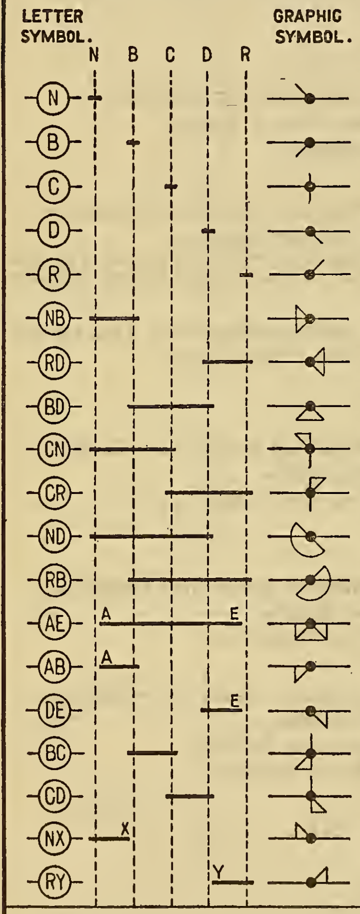
DESIGNATE RESISTANCE IN OHMS OF ALL D.C. RELAYS, INDICATORS AND LOCKS.

CIRCUIT CONTROLLERS OPERATED BY LEVERS.

USE EITHER LETTER SYSTEM OR GRAPHIC SYSTEM.

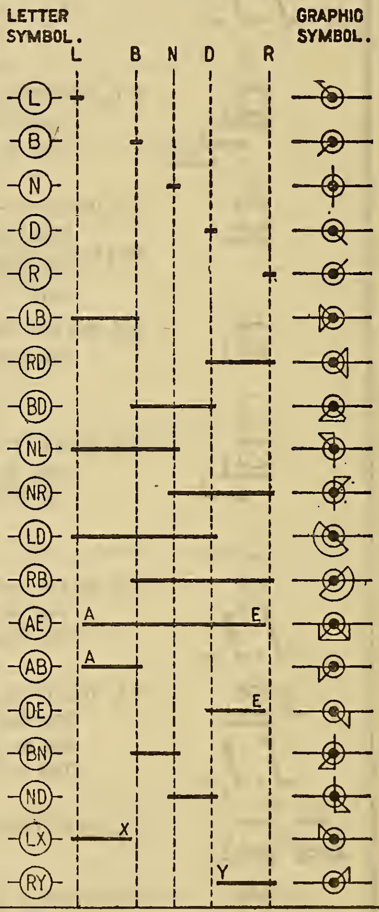
LEVERS WITH EXTREME END POSITION AS NORMAL.

N–FULL NORMAL POSITION OF LEVER
B–NORMAL INDICATION POSITION.
C–CENTRAL POSITION.
D–REVERSE INDICATION POSITION.
R–FULL REVERSE POSITION.



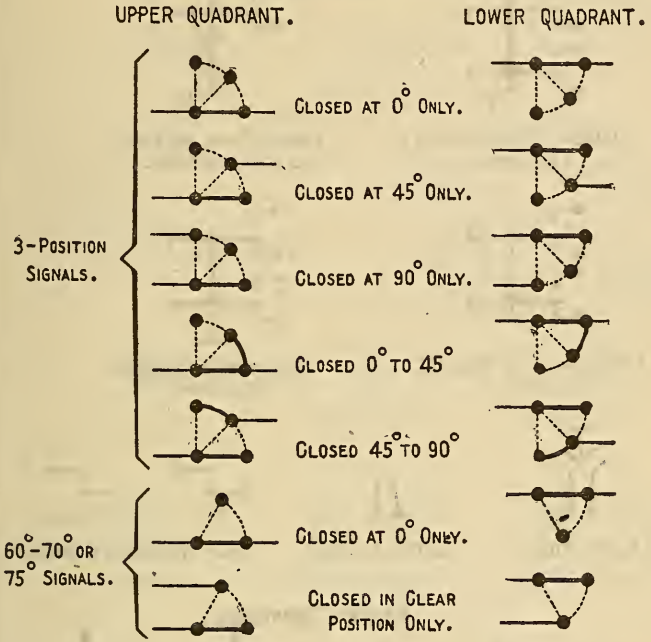
LEVERS WITH MIDDLE POSITION AS NORMAL.

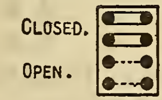
N–NORMAL POSITION.
L–FULL REVERSE POSITION TO THE LEFT.
B–INDICATION POSITION TO THE LEFT.
D–INDICATION POSITION TO THE RIGHT.
R–FULL REVERSE POSITION TO THE RIGHT.



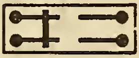
NOTE: HEAVY HORIZONTAL LINES INDICATE PORTION OF CYCLE OF LEVER THROUGH WHICH CIRCUIT IS CLOSED.

CIRCUIT CONTROLLERS OPERATED BY SIGNALS.

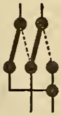




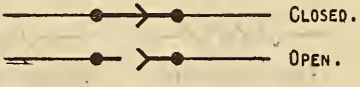
SWITCH CIRCUIT CONTROLLER.



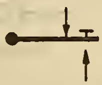
CIRCUIT CONTROLLER OPERATED BY LOCKING MECHANISM OF A SWITCH MOVEMENT.



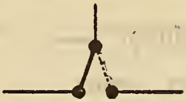
POLE CHANGING CIRCUIT CONTROLLER.



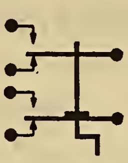
BRIDGE CIRCUIT CONTROLLER.



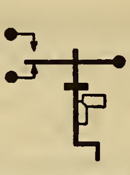
SPRING HAND KEY OR PUSH BUTTON.



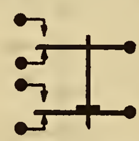
CIRCUIT SWITCH.



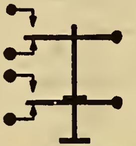
Manual Time Release.
(Electric)



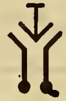
Manual Time Release.
(Electro-Mechan'l.)



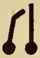
Automatic Time Release.
(Electric)



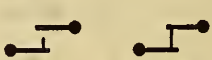
Emergency Release.
(Electric)



Floor Push.



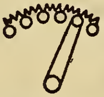
Latch Contact.



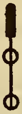
Open. Closed.

Track Instrument Contact.

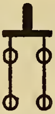
Knife Switches.



Rheostat.

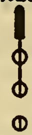


Single Pole.

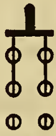


Double Pole.

Single Throw.



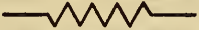
Single Pole.



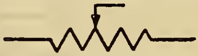
Double Pole.

Double Throw.

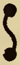
Quick Acting Circuit Controllers may be Distinguished by the Letter "Q"



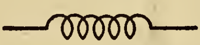
Fixed Resistance.



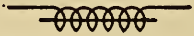
Variable Resistance.



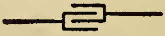
Fuse.



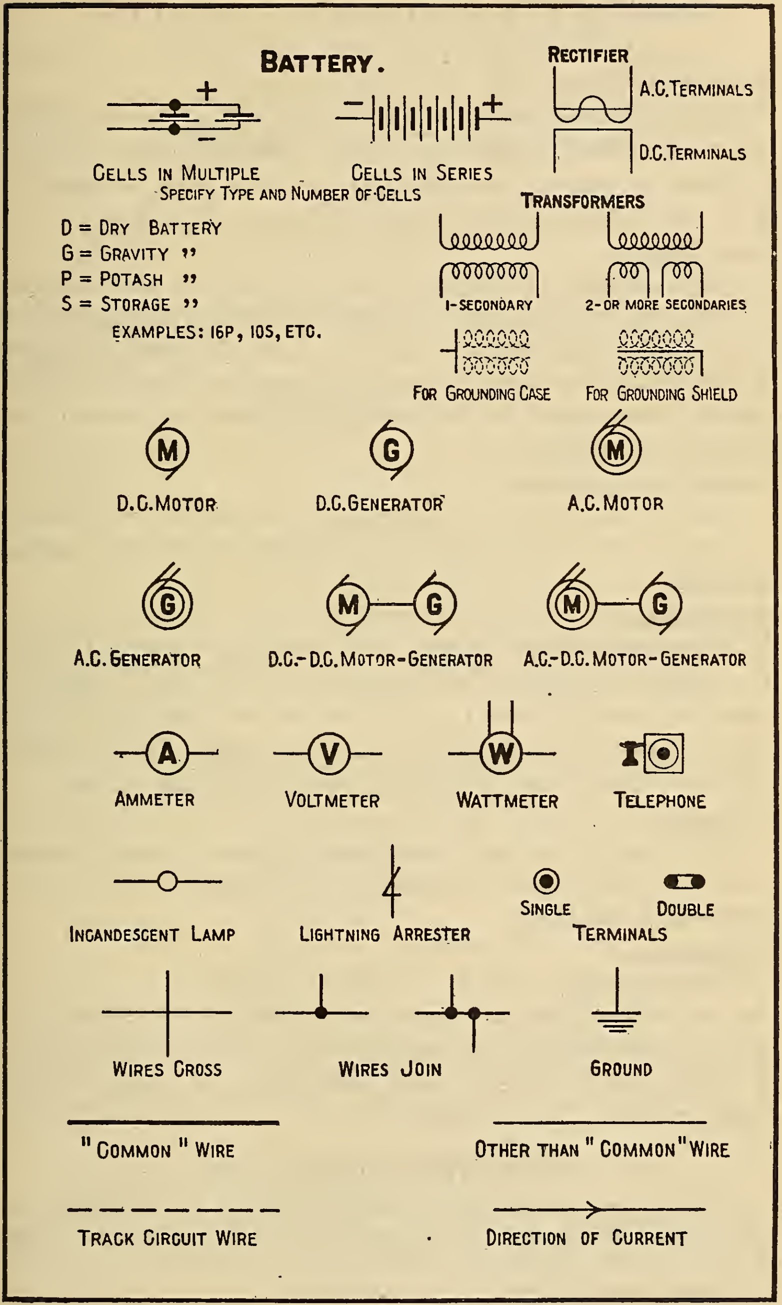
Impedance without Iron Core.



Impedance with Iron Core



Condenser.


BATTERY.
+
−
Cells in Multiple
Cells in Series
Specify Type and Number of Cells
D = Dry Battery
G = Gravity ”
P = Potash ”
S = Storage ”
Examples: 16P, 10S, etc.
Rectifier
A.C. Terminals
D.C. Terminals
Transformers
1-Secondary
2-or more Secondaries
For Grounding Case
For Grounding Shield
M
D.C. Motor
G
D.C. Generator
M
A.C. Motor
G
A.C. Generator
M G
D.C.-D.C. Motor-Generator
M G
A.C.-D.C. Motor-Generator
A
Ammeter
V
Voltmeter
W
Wattmeter
Telephone
Incandescent Lamp
Lightning Arrester
Single
Double
Terminals
Wires Cross
Wires Join
Ground
"Common" Wire
Other than "Common" Wire
Track Circuit Wire
Direction of Current

[8] REASONS FOR MAINTAINING A STOREHOUSE.

The following statement embodies the general principles governing the economical management of a railway storehouse:

The object of a storehouse is to provide material and tools when required so that the cost of work may be a minimum, bearing in mind the factors of delay to work and labor, also interest on investment in stock. The following essential elements enter into the problem:

Standardization.

The standardization of materials and instructions in regard to their use will reduce to a minimum the number of items of material of the various classes which should be carried in stock. The amount of each item which should be carried in stock will depend upon the rate of consumption, time required for the purchase and delivery of material, and also upon local conditions.

Classification of Material.

This is necessary so as to reduce to a minimum the cost and time of handling. An approved classification should be followed in making requisitions.

Stock Account.

An account should be kept of stock showing at all times a record of receipts, disbursements and amount on hand. Stock should be replenished when the amount of any item has been reduced to a fixed minimum. Inventories should be made at stated periods. A proper stock account furnishes a check on excessive supply and obsolete material.

Distribution.

When material is shipped, notice should be sent to consignee showing partial or complete filling of requisition, and if partial, when final shipments may be expected.

Organization.

The storekeeper's place in the general organization should be so fixed and adjusted that the measure of his efficiency is, primarily, the promptness and accuracy with which he fills requisitions, and, secondly, his ability to hold down the stock investment to the lowest amount consistent with the first requirement.

[9] PROTECTION OF RECORDS.

Duplicate copies of record books and maps, particularly right-of-way maps, should be kept in quite widely separated localities, so that the trouble and expense of reproducing them will be greatly reduced in case of fire or accident.

---

[8] Adopted, Vol. 13, 1912, pp. 506-507, 996-997.

[9] Adopted, Vol. 5, 1904, pp. 286, 371, 377 (see Vol. 2, 1901, p. 322); Vol. 6, 1905, pp. 658, 668.

COMMITTEE XII.

RULES AND ORGANIZATION.

[1]MANUAL OF INSTRUCTIONS FOR THE GUIDANCE OF ENGINEERING FIELD PARTIES

SECTION I

Size of Field Party

The size of the field party will depend upon the work to be handled. In all cases sufficient intelligent help should be employed to assure accuracy of results.

Minimum party:

Instrumentman.
2 Chainmen.

The party should be increased to meet the requirements of the work to be done.

SECTION II

Before Going Into the Field

The Chief of Party is responsible to his superiors for results and to his men in the field for their welfare. The Chief of Party should therefore familiarize himself as much as possible with the conditions to be met before starting out.

Transportation

The following items should be investigated or anticipated by the Chief of Party before starting on any expedition.

Which of the modes of travel will likely be used?

Steam railway,
Electric railway,
Automobile,
Motor car,
Horse and wagon train,
Pack train,
Boats,
Dog sleds, etc.

If one mode of travel is not used continuously, what source of supply can he depend on for other means of conveyance when the change comes, as, for instance, boats when the river is reached and automobiles are abandoned.

Availability of gasoline and oils for motor vehicles, if used.

Availability of forage for animals, if used.

Difficulties liable to be encountered with the mode of travel selected—difficulties with automobiles, dog teams or canoes.

---

[1] Adopted, Vol. 22, 1921, pp. 797, 1078.

Personnel of Field Party

The selection of the various members should rest with the Chief of Party.

The physical condition of the men selected for the work should be investigated. He should satisfy himself whether or not each individual will be able to stand the climate, the altitude, the swamps, etc.

Where local people are available for non-technical positions, they should be employed as members of the party to the greatest number possible, to gain the benefit of their information on local conditions.

Personal Supplies

The Chief of Party should instruct the men as to the amount and kind of clothing as a minimum, dependent upon the length of time they expect to be on the expedition, and the kind of climate and the extremes of temperature to be encountered, and the ability to secure such supplies en route. Also the maximum limit permissible in weight or bulk due to the transportation facilities.

Camp Equipment

With the advice and instruction of his superior the Chief of Party should decide upon the kind of equipment that will be necessary, depending upon methods to be used in housing and taking care of the men.

If in hotels, the spacing and capacity.

If in farm houses, the spacing of groups or settlements and the capacity.

If in camp cars, the number and kind required, and sufficient water supply to accompany.

If in tents, the strength and design necessary to combat storms, wild animals or insects. Also whether stoves, wooden floors, flies, etc., are needed in certain seasons. And in certain countries it will be necessary to consider fever protection, mosquito head nets and gloves, mosquito proof tents, snow shoes, snow glasses, portable boats, ropes for rafting and climbing, hammocks for sleeping, ant protection, etc.

Supplies

Under the instructions and advice of the Chief Engineer, the Chief of Party will be informed and prepare for the following:

The kind and amount of supplies required for some period of time considering the size of the party to be handled.

The mode of securing replenishment of supplies, so as to have only the actual quantity required on hand, and thus reduce transportation difficulties when moving camp.

First aid outfits and instructions for their use.

Additional medical supplies and instructions for their use; the quantity and assortment to depend upon the likelihood of the requirements and degree of civilization and density of population.

The source of provisions for food.

The methods to be employed for preserving foods of certain kinds or the necessity of eliminating certain foods on account of inability to preserve them, and the substitutes that can be used therefor.

Camp Locations

Something should be known of conditions likely to be met in camp locations and preparations made beforehand to meet them, having in mind the following:

Sanitary facilities required, dependent upon the duration of the stay at any one place, and the effect of stream pollution on the surrounding territory.

The methods of providing for such facilities.

The methods to be used in taking down, moving and setting up camp so as to lose the least amount of time.

The design of the camp to meet the local requirements.

Communication

Methods of securing mail and other sources of communication that can be arranged.

SECTION III

After Arriving in the Field

After the party arrives in the field, the Chief of Party should not be overburdened with details of the survey, but should have ample time to look forward and anticipate requirements to overcome the conditions that will be met, and he should detail the methods of handling the work covering the following items:

Organization

Duties of the various members.

The duties under different circumstances for the different periods of the day should be outlined, as far as practicable, such as:

What each member shall do when starting the day,
When completing the day,
When breaking camp,
When setting up camp, and
While in camp.

The assembling of the entire party or each sub-division at the close of the day's work, so all may return to camp together, and thereby avoid being lost in the woods or meeting with an accident, and none to assist them to camp.

Supplies and Equipment

The Chief of Party is expected to instruct in regard to the following:

That care is used in handling all supplies and equipment.

That wastefulness is avoided.

That extreme care is used in handling and transporting instruments.

Designate methods to be used when instruments and other equipment are left in the field over night.

That the personal equipment and clothing of the men bear individual markings or distinctive colors sufficient to keep one man's possessions from being mixed with others.

Treatment of Property Belonging to Others

The Chief of Party is responsible for:

The amount of care to be exercised when going through cultivated fields.

The general rules as to whether timber should be cut and when to triangulate around it.

The location at which hubs are to be set for permanency and the kind of stakes to be used through grain fields to avoid damage to farm machinery, or the removal of such stakes after the party has passed.

The cutting of stakes from timber, or material at hand, as the party passes along, so as to avoid using property upon which others may set a value.

Conduct of Party

Everything should be done to create a good feeling among residents, as you may want favors and may have to return; if not yourself, others on similar expeditions.

Violate no local customs, and take care not to run counter to any local prejudices, but conciliate the good feeling of the community.

When stopping at farm houses, you must realize the people are inconvenienced in order to accommodate you. Leave things as you find them.

Records

The method of keeping field notes should be uniform throughout the entire survey. Such details must be outlined in order to secure results.

The field notes should be kept in such a manner that they may be platted without loss of time and may be readily interpreted by others who may have to use them in the future. All notes should be indexed and titled, and the lines named, lettered, or numbered, and the whole carefully kept for future use.

Maps should be of the size and scale prescribed by the Chief Engineer.

Signs and symbols should conform with the Manual of the A.R.E.A.

Property lines should be tied in on the notes and the maps.

Abandoned lines should be crossed out and marked abandoned.

Maps and notes should have sufficient information to place them:

Name of the railroad.
Branch or division.
Town and state.
Object.
Date survey began; date finished.
Scale.
North point.

The name of the Engineer in charge and the person making the notes.

The start and ending of each day's work should be noted on the page of the book where the notes begin and end for that day's work.

Transit field notes should show:

Station.

Point.

Deflection.

Angle to right.

Angle to left.

Calculated course.

Magnetic course.

All in columns as stated from left to right.

Each page should have across the top the name of the line and the kind of survey. Notes should run up the page.

Topography notes:

Each page should have across the top the name of the line and the kind of survey.

Datum.

Interval.

Scale, should be plainly set out at the beginning and the end of each line.

Reference Points and Bench Marks

The Engineer will be judged by what he leaves behind him, and how he left it. These things which he leaves behind him are his notes, his maps and his reference points. It should be the purpose to use such judgment that the reference points are as permanent as possible.

When the line is finally established, bench marks should be placed on permanent locations, and a large number of alinement points should be referenced in a permanent manner. Iron posts or stone monuments buried along property lines and their location tied to other known corners are probably the best. Also prominent features on country residences are good, gables, chimneys, etc. They should be lined in by the three-point problem, three angles, three points, and the bearing calculated, if possible. The magnetic bearing should also be given.

[2]MANUAL OF RULES FOR THE GUIDANCE OF EMPLOYEES OF THE MAINTENANCE OF WAY DEPARTMENT

General Notice

To enter or remain in the service is an assurance of willingness to obey the rules.

Obedience to the rules is essential to the safety of passengers and employees, and to the protection of property.

The service demands the faithful, intelligent and courteous discharge of duty.

---

[2] Adopted, Vol. 22, 1921, pp. 802, 1082.

To obtain promotion capacity must be shown for greater responsibility.

Employees, in accepting employment, assume its risks.

General Rules

1. Employees whose duties are prescribed by these rules must provide themselves with a copy.

2. Employees must be conversant with and obey the rules and instructions. If in doubt as to their meaning, they must apply to the proper authority for an explanation. Supervisory employees must know that the rules and instructions are understood and complied with by those under them.

3. Employees must pass the required examinations.

4. Any violation of the rules or instructions must be reported.

5. The use of intoxicants by employees while on duty is prohibited. Their use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

6. In case of danger to the Company's property, employees must unite to protect it.

7. Safety is of the first importance in the discharge of duty. In all cases of doubt or uncertainty, the safe course must be taken.

8. Employees must do all in their power to prevent accidents, even though in so doing they may necessarily perform the duties of others.

9. No employee is allowed to contract any bill or other obligation on account of the Company or to use the Company's credit, unless authorized by the proper officer.

10. Assignment of wages by employees is prohibited and will be sufficient cause for dismissal. Employees failing or refusing to pay their just debts, or against whom bills are frequently presented to the Company for payment, or whose wages have been garnisheed, will, unless satisfactory reason be given, be dismissed from the service.

11. Employees must devote themselves exclusively to the service, and must not connect themselves with any other trade or business without permission from the proper officer.

12. Employees must not absent themselves from duty without permission. They must not exchange duties with others, or engage substitutes without proper authority.

13. The articles furnished by the Company for the use of employees must, on their leaving the service, be returned to the proper officer.

14. Employees subject to emergency call must keep their immediate superior and the train dispatcher informed as to their whereabouts at all times.

15. Each employee whose duties are in any way affected by it, must have a copy of the current time table and be familiar with the rules and regulations therein. He must have it with him when on duty and know the time of trains at whatever point he may be working.

Employees must carefully observe signals displayed by all trains, and assure themselves before obstructing the track that all trains and sections due have passed.

Employees are especially cautioned that extra and special trains may be run at any time and trains may run at any time upon any track in either direction, without notice to them. They must be governed accordingly and exercise proper care to avoid accident.

16. Employees are forbidden to ask or receive fees or contributions from subordinates, co-employees, or the public.

17. Employees will be subject to record discipline, suspension, or dismissal for cause.

18. Employees must know that the machinery, tools and appliances which they are expected to use and are about to use, are in suitable and proper condition for use.

19. Employees will be regarded as in line of promotion, or advancement, depending upon the faithful discharge of duty and capacity for increased responsibility.

20. A complete service and discipline record of all supervising employees should be kept in the office of ....

21. Employees must observe trains closely, and if anything dangerous is noted, must call attention of the trainmen to the fact by signal or wire.

22. When work, or other cause, renders the track or bridges unsafe for passage of trains, protection to trains must be provided in accordance with instructions.

When the track is safe for trains to pass, but at reduced speed, protection must be provided by displaying the proper signals from each end of the section of track on which the speed is restricted. Resume signals should be displayed to indicate where the normal speed may be resumed. On multiple tracks each track involved must be protected in the same manner as if it were single track.

The Superintendent must be notified at once by wire of the speed to be observed over the track protected by "Slow" signals. Where the obstruction of a track is continued during the night, proper night signals must be displayed.

23. In case of impassable or obstructed track, flagging is the first duty and repairs must wait, if necessary, until signals have been displayed.

24. No work that will interfere with the safe passage of trains at full speed must be undertaken during fogs or blinding storms, except in emergency.

25. Disregard of stop or caution signals, excessive speed of trains, or failure to answer signals properly must be reported, with a full statement of facts.

26. Employment of minors will not be permitted, except as allowed by law, and then only after written consent and release on the proper form has been obtained from parents or guardians.

27. When a train is approaching or passing, employees must not unlock a main track switch nor stand within .... feet of such a switch.

Immediately upon closing and locking a main track switch, the employee doing so will observe if the points fit properly, and must call the attention of those with him in words equivalent to the statement: "I have closed and locked the switch." This statement must be acknowledged in words by one of the employees to whom it is addressed.

28. Motor, hand, velocipede and push cars must be used for Company business only, and must be operated in accordance with the special rules governing their use.

29. In case of injury, however slight, to himself or to any one under his supervision, or in case of injury to others which has not been reported by other employees, the Foreman must immediately make a report by wire to his Supervisor, followed by a written report on the prescribed form.

30. The Company should be informed promptly regarding contemplated public improvements or enacted ordinances which would in any way affect its interests. Supervisors, Foremen and other employees must make prompt report and forward at once to their immediate superiors any printed public notices or other matter, with all the information available.

31. Employees must not use the telegraph unnecessarily. All messages should be as brief as is consistent with a clear understanding of their meaning.

32. Employees must not permit, except by proper authority, experimental trials of appliances or devices, nor give out information of the results of any such trial.

33. Employees shall conform to the prescribed standards, plans and specifications in the execution of work under their supervision.

OPERATING RULES

(Any rule preceded by a number in parentheses is a Standard-Code rule of the American Railway Association of that number.)

Standard Time

34. (1) Standard time obtained from .... observatory, will be transmitted to all points from designated offices at ....M. daily.

35. (2) Watches that have been examined and certified to by a designated inspector must be used by conductors, enginemen and .... The certificate in prescribed form must be renewed and filed with the .... every ....

(Form of Certificate)

Certificate of Watch Inspector

This is to certify that on....................................., 19....
the watch of..
employed as ....
on the ....R..................

was examined by me. It is correct and reliable, and, with proper care should run within a variation of thirty seconds per week.

Name of Maker..
Grade ....
Number of Movement...
Open or Hunting Case..
Metal of Case..
Signed...
Inspector.
Address.................................

36. (3) Watches of conductors and enginemen and .... must be compared before commencing each day's work, with a clock designated by time-table as a standard clock. The time when watches are compared must be registered on a prescribed form.

37. If access to a standard clock is not possible comparison will be made with a responsible employee who has compared with a standard clock.

38. (7) Employees whose duties may require them to give signals, must provide themselves with the proper appliances, keep them in good order, and ready for immediate use.

39. (8) Flags of the prescribed color must be used by day, and lights of the prescribed color by night.

40. (9) Day signals must be displayed from sunrise to sunset, but when day signals cannot be plainly seen, night signals must be used in addition. Night signals must be displayed from sunset to sunrise.

41. (10) *Color-Signals.*

	Color	*Indication*
(a)	Red.	Stop.
(b)	———	Proceed with caution and for other uses prescribed by the rules.
(c)	———	Proceed, and for other uses prescribed by the rules.
(d)	Green and White.	Flag Stop. See Rule 58 (28).
(e)	Blue.	See Rule 56 (26).
(f)	Purple.	Stop (night indication for dwarf signals.

42. (11) A train finding a fusee burning on or near its track must stop and extinguish the fusee, and then proceed with caution prepared to stop short of train or obstruction.

43. Maintenance of Way employees must not disturb burning fusees on or near the track placed there by trainmen.

44. (12) *Hand, Flag and Lamp Signals.*

	Manner of Using	*Indication*
(a)	Swung across the track.	Stop.
(b)	Held horizontally at arm's length, when the train is moving.	Reduce speed.
(c)	Raised and lowered vertically.	Proceed.
(d)	Swung vertically in a circle at half-arm's length across the track when the train is standing.	Back.
(e)	Swung vertically in a circle at arm's length across the track, when the train is running.	Train has parted.
(f)	Swung horizontally above the head when the train is standing.	Apply air brakes.
(g)	Held at arm's length above the head when the train is standing.	Release air brakes.

45. (13) Any object waved violently by anyone on or near the track is a signal to stop.

46. (14) *Engine and Motor Whistle Signals.*

NOTE.—The signals prescribed are illustrated by "o" for short sounds; "—" for longer sounds. The sound of the whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

Sound	*Indication*
(a) o	Apply brakes. Stop.
(b) — —	Release brakes. Proceed.
(c) — o o o	Flagman protect rear of train.
(d) — — — —	Flagman may return from west or south, as prescribed by Rule 64 (99).
(e) — — — — —	Flagman may return from east or north, as prescribed by Rule 64 (99).
(f) — — —	When running, train parted, to be repeated until answered by the signal, as prescribed by Rule 44 (12), (e). Answer to Rule 44 (12), (e).
(g) o o	Answer to any signal not otherwise provided for.
(h) o o o	When train is standing, back. Answer to Rule 44 (12), (d).
(j) o o o o	Call for signals.
(k) — o o	To call the attention of yard engines, extra trains or trains of the same or inferior class or inferior right to signals displayed for a following section. If not answered by a train, the train displaying signals must stop and ascertain the cause.
(l) — — o o	Approaching public crossings at grade.
(m) ————	Approaching stations, junctions, railroad crossings at grade and ....
(n) — — o	Approaching meeting points.
(o) o —	Inspect train line for leak.
(p) Succession of short sounds.	Alarm for persons or live stock on the track.

47. (15) The explosion of two torpedoes is a signal to reduce speed and lookout for a train ahead or obstruction. The explosion of one torpedo will indicate the same as two, but the use of two is required.

48. (17) The headlight will be displayed to the front of every train by night, but must be concealed when a train turns out to meet another and has stopped clear of main track, or is standing to meet trains at the end of double track or at junctions. When an engine is running backward a white light must be displayed by night on the rear of the tender.

49. (18) Yard engines will display the headlight to the front and

rear by night. When not provided with a headlight at the rear, a white light must be displayed. Yard engines will not display markers.

50. (19) The following signals will be displayed, one on each side of the rear of every train, as markers, to indicate the rear of the train: By day, green (or yellow) flags, or marker lamps (not lighted). By night, green (or yellow) lights to the front and side and red lights to the rear; except when the train is clear of the main track, when green (or yellow) lights must be displayed to the front, side and rear.

51. (20) All sections except the last will display two green flags, and, in addition, two green lights by night, in the places provided for that purpose on the front of the engine.

52. (21) Extra trains will display two white flags and, in addition, two white lights by night, in the places provided for that purpose on the front of the engine.

53. (22) When two or more engines are coupled, each engine shall display the signals as prescribed in Rules 51 (20), 52 (21).

54. (23) One flag or light displayed where in Rules 50 (19), 51 (20) and 52 (21) two are prescribed will indicate the same as two; but the proper display of all train signals is required.

55. (24) When cars are pushed by an engine, except when shifting or making up trains in yards, a white light must be displayed on the front of the leading car by night.

56. (26) A blue signal, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it; when thus protected, it must not be coupled to or moved. Workmen will display the blue signals and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals, without first notifying the workmen.

Use of Signals

57. (27) A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as the most restrictive indication that can be given by that signal, and the fact reported to the .... Conductors and enginemen using a switch where the switch light is imperfectly displayed or absent, must also, if practicable, correct or replace the light.

58. (28) A green and white signal will be used to stop a train only at the flag stations indicated on its schedule. When it is necessary to stop a train at a point that is not a flag station on its schedule, a red signal must be used.

59. (29) When a signal, except a fixed signal, is given to stop a train, it must, unless otherwise provided, be acknowledged as prescribed by Rule 46 (14) (h).

60. (30) The engine-bell must be rung when an engine is about to move and while approaching and passing public crossings at grade.

61. (31) The whistle must be sounded at all places when required by rule or by law.

62. (33) Watchmen stationed at highway crossings must use stop

signals when necessary to stop trains. They will use .... signals to stop highway traffic.

63. (35) The following signals will be used by flagmen:

Day Signals—A red flag, torpedoes, and fusees.

Night Signals—A red light, a white light, torpedoes, and fusees.

64. (99) When a train stops under circumstances in which it may be overtaken by another train, the flagmen must go back immediately with flagmen's signals a sufficient distance to insure full protection, placing two torpedoes, and when necessary, in addition, displaying lighted fusees.

When signal 46 (14), (d) or 46 (14), (e) has been given to the flagman and safety to the train will permit, he may return. When the conditions require he will leave the torpedoes and a lighted fusee.

The front of the train must be protected in the same way, when necessary, by the ....

When a train is moving under circumstances in which it may be overtaken by another train, the flagman must take such action as may be necessary to insure full protection. By night, or by day when the view is obscured, lighted fusees must be thrown off at proper intervals.

When day signals cannot be plainly seen, owing to weather or other conditions, night signals must also be used.

Conductors and enginemen are responsible for the protection of their trains.

65. Motor, hand, velocipede and push cars, when in use, must be protected as prescribed by rule 64 (99).

Rules for the Government of Employees Working On or About the Track

66. It is the duty of every employee working on or about the track, to exercise care to avoid injury to himself and others.

67. On the approach of a train, employees who are working on or about the track, must move to a place of safety, standing clear of all running tracks. They must not work or stand on the tracks, except when necessary for the proper performance of their duties.

68. Watchmen, Patrolmen, Trackwalkers and others on duty, which makes it necessary for them to be on the track, where there are two or more tracks, should, when practicable, travel against the current of traffic, keeping sharp lookout in both directions for approaching trains.

69. Foremen or others in charge of employees, working on or about the tracks, must instruct their men to be alert, watchful, and to keep out of danger; and will take the necessary precautions to see that all men working under their immediate supervision receive warnings of approaching trains in time to reach a place of safety.

70. Foremen, Watchmen and others in charge of gangs or squads of workmen, should provide themselves with a whistle and should use same in warning the men of approaching trains, or when it is necessary for them to clear the tracks and move to a place of safety.

71. When large numbers of inexperienced men are working on the track, it is desirable to divide them into small squads, and place each squad in charge of an experienced man, and take such other additional precautions as will provide for the safety of the men.

72. In handling rails, ties and other heavy materials, special care must be used to avoid injury.

73. Employees working in a tunnel or near the end of same, when a train approaches from either direction, must stand clear of all tracks, and if in the tunnel should occupy the man holes. If there is insufficient clearance or no man holes, arrangement must be made to work under flag protection.

74. Employees are required to carry lights when passing through any tunnel where men cannot readily be seen. When an entire gang is working close together, an adequate number of lights should be used, but not less than two.

75. Motor, hand, velocipede or push cars must not be used when approaching trains cannot readily be seen by reason of fog, storm or snow, except under proper protection.

76. Any employee, who while on duty, is careless about the safety of himself or others or who disregards warnings, will be disciplined.

77. Foremen, Watchmen and others in charge of gangs or squads of workmen, should consider it their personal duty to assist in keeping the tracks, yards and foot paths along them free of any obstacle which might be the cause of injury to others.

Rules for the Operation of Motor, Hand, Velocipede and Push Cars

78. Employees to whom cars are assigned are responsible for the proper use and condition of cars in their charge. A report must be made to their superior officer if the car is in need of repairs or is, in their opinion, unsafe to operate.

79. No one except a responsible employee who has been properly qualified will be allowed to operate motor, hand or velocipede cars upon the main track.

80. Before cars are used, an inspection must be made to be sure that the running gear, brakes, etc., are in good operating condition; that a sufficient supply of gasoline is in the tank of motor cars and that the car is properly lubricated. After the car is started, the brakes must be tested immediately to be sure that they are in working condition.

81. Motor, hand and velocipede cars are to be used only for transporting workmen and tools. Heavy material must not be carried on them, except in emergency. Push cars must be used to transport such heavy materials as ties, rails, frogs, etc.

82. Employees must not get on or off a moving car from the front or side. The use of seats on the ends of hand or push cars is forbidden.

83. Tools must be placed on cars with care. Track jacks or other tools must not be carried on the front of the car.

84. Employees operating motor, hand or velocipede cars must pro-

vide themselves with whistle or other device, which must be sounded at all highway grade crossings and at all other points when necessary to warn workmen or others of the approach of the car.

85. Employees operating cars on main tracks shall, when practicable, obtain information regarding trains, but such information will not relieve them from the responsibility of protecting their cars. They will see that their cars are clear of the main track for regular scheduled trains and, when blocked by an operator or the dispatcher, will report clear when out of the block or clear of the main track. No open telegraph office should be passed without stopping and ascertaining the location of all trains.

86. Where practicable, cars should be run on outside main tracks or on sidings in the direction of traffic. A sharp lookout should be maintained in both directions, where possible.

87. When approaching road crossings at grade, the car must be under complete control, and the employee in charge must know that highway travelers will not be endangered, before going on the crossing. If the crossing is protected by flagman, the operator must get signal from him before proceeding. When required by rule or law, a proper warning must be given approaching all highway crossings at grade.

88. Cars must not exceed a speed of *8 miles per hour* when passing through stations or yards, over switches or through interlocking, over frogs, railroad, highway or farm crossings at grade. At all other points, hand cars are restricted to *10 miles per hour* and motor cars to *20 miles per hour.* Cars must be stopped, when practicable, during passage of a train on an adjacent track.

89. Cars must be operated with care in passing trains receiving or discharging passengers at stations and must not be run between such trains and the station.

90. Motor cars should not be run through the spring rail side of frogs. Main track switches must not be opened to use siding for cars except when loaded too heavy to lift over the rails. When necessary to open the switch for a loaded car, the employee in charge of the car shall personally unlock and lock the switch as provided in Rule 27.

91. Cars must not be attached to engine or trains nor run closer than 500 feet behind moving trains.

92. The space between two or three hand cars when running should not be less than 300 feet; that between two or three motor cars or a hand car and a motor car should not be less than 600 feet. A car in advance must not be stopped until the following car has been signaled. The employee in charge of two or three cars so run must ride on the second car. When more than three cars are run, they must be divided into groups of three or less, the front car of each group being run not less than 1,200 feet behind the last car of the preceding group, and each group being run as specified above.

93. When motor, hand, velocipede or push cars are operated at night or during fog, storm, snow or through tunnels, they must be equipped with a white light in front and a red light to the rear.

94. Cars must be removed from the track or protected by flag when not in use. When they cannot be removed from the track to clear an approaching train, they must be protected as required by Rule 64 (99).

95. A copy of the current timetable must be carried on all hand and motor cars and, in addition, the following signal equipment:

— torpedoes
2 red flags
2 red lanterns
2 white lanterns
– fusees

96. Torpedoes exploded by motor, hand, velocipede or push cars must be replaced.

97. Cars must not be overloaded. Brakes should be applied gradually, and emergency stops should be made only when absolutely necessary.

98. Hand and push cars should not be run with motor cars, but if necessary to do so, they must be coupled behind and never pushed ahead. When hand or push cars are coupled, the speed of the motor car must be reduced to the maximum speed provided for hand cars in Rule 88.

99. Employees in charge of motor cars must not permit occupants to sit in insecure or careless positions, nor permit any smoking or uncovered lights around motor cars when tanks are being filled or gasoline handled. Motor cars must not be inspected with matches or torches. All moving parts should be guarded.

100. Motor cars must not be shipped on trains unless absolutely necessary. When necessary to ship them, the gasoline tanks must be drained.

101. Only insulated cars should be used where there are track circuits.

102. When cars are removed from the track they must be placed not less than five feet from the near rail, and so located that they cannot foul the track. They must not be set off or left standing within the full legal width of highway or private road crossing at grade, except in cases of emergency. When necessary, on account of emergency, in clearing trains, cars may be set off at crossings but must be protected by an employee and immediately removed when the emergency is passed. They must be kept locked when not in sight of the men in charge and, at night, and at other times, when not in use, should be kept under cover.

Organization—Duties of Divisional Maintenance Officers

103. On a division some one officer is usually in charge of the Maintenance of Way Department and reporting to him are subordinate officers who are directly responsible for the maintenance of:

Tracks and Roadway
Bridges and Buildings
Signals and Interlocking

The duties of these officers, as hereinafter outlined, are typical and of general application to the respective positions, regardless of the title the individual occupying the position may have. The divisional officer in charge of the Maintenance of Way Department is the Division Engineer to whom report:

The Supervisor of Track
The Supervisor of Bridges and Buildings
The Supervisor of Signals

These subordinate divisional officers, each in his respective department, have Foremen and others reporting to them. The Foreman, usually, is the officer under whose immediate supervision the skilled and unskilled labor perform their work.

Division Engineers

104. Division Engineers report to and receive instructions from the ....

105. They are responsible on their respective divisions for such Maintenance of Way matters as are assigned them. They will have supervision over the persons employed in their department, see that they understand and obey the rules and regulations in force, and that the work is carried on in a proper, careful and economical manner; that the records of time and material are correctly and properly kept, and that the necessary and required reports, covering the time worked and the material used, are promptly and properly made.

Supervisors of Track

106. Supervisors of Track report to and receive instructions from the Division Engineer.

107. They are in charge, in their respective districts, of the maintenance of tracks, their appurtenances and of the employees engaged thereon.

108. They shall have immediate supervision of work train service for the maintenance of tracks, using such service only when properly authorized by the Division Engineer.

109. They must make the prescribed inspections of track, roadway, station grounds, and driveways under their charge and when necessary arrange for prompt repairs of any defects or improper conditions found.

110. They must know that the Foremen, track laborers and others under their supervision fully understand and properly perform their duties; keep account of, and report their time in the manner prescribed and discipline them when necessary.

111. They must know that the Foremen are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

112. They shall keep themselves informed in regard to all work performed upon tracks and roadway in their districts, by contractors or others, who may not be under their supervision; see that the work is done in such a way as not to endanger the safety of tracks or roadway

and report promptly to the proper officer, if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

113. In case of damage to tracks or roadway, they shall promptly assemble men and material, proceed to the place of accident as quickly as possible and make the necessary repairs. They shall investigate all accidents to track and roadway and report promptly to the proper officer on the prescribed form.

114. They must know that the vicinity of all bridges and trestles is clear of combustible matter, and that the bridge seats, tops of the piers and other readily accessible portions of bridges and trestles are clear of cinders and dirt, and that the water barrels are kept full of water.

115. They shall see that the waterways and the approaches and outlets thereto are free from obstructions.

116. They shall not permit encroachment upon or occupancy of any portion of the Company's buildings, right-of-way or station grounds, except upon proper authority.

Section Foremen

117. Section Foremen report to and receive instructions from the Supervisor of Track.

118. Unless otherwise directed, Section Foremen will have immediate charge of, and be responsible for the safe condition of tracks, roadway, and right-of-way on their sections, and for the economical use of labor and material in their maintenance. They must do no work thereon that will interfere with the safe passage of trains, except under proper protection.

119. Each Foreman must go over his section, or send a competent, reliable man with suitable tools, at designated intervals, to make a thorough inspection, and see that the track, culverts, highway crossings, bridges, fences, etc., are in safe condition. If, in his judgment, the track or any bridge or culvert is not safe, he must at once put out proper signals to warn approaching trains, notify the Supervisor of Track, Division Engineer and the Superintendent of the condition and do everything in his power to make the necessary repairs.

120. Section Foremen will have full charge of all forces under them, and shall employ the number of men the Supervisor of Track directs. They must see that their men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of the material furnished them.

121. In case of accident, Section Foremen must immediately proceed to the scene and render all assistance in their power, whether the accident occurs on their own or a neighboring section.

In the absence of the Supervisor or other ranking officer, the Section

Foreman on whose section the accident occurs, will have charge of the assembled track forces, and shall be responsible for the character of the repairs made. He must not allow the track to be used until it is known to be safe.

122. Section Foremen shall investigate all accidents resulting in derailment or in damage to the track, roadway, or structures on their sections, and report on the prescribed form, giving the cause, as nearly as they are able to ascertain it.

123. They must keep themselves informed in regard to work performed on their sections by contractors or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of tracks or the safe passage of trains.

124. They shall make a personal inspection of their sections at designated intervals, examining particularly main track switches and frogs, looking for concealed defects or breaks.

125. They must give special attention to points where obstructions are likely to occur, examine the slopes of cuts, and promptly remove all earth, trees, rocks, or anything likely to fall or slide upon the track, reporting such conditions to the Supervisor of Track.

126. Section Foremen shall maintain surface ditches in such a manner that the surface water is carried beyond the cut.

127. Section Foremen must keep the ditches and waterways leading to and from bridges and culverts clear within the limits of the right-of-way. They must remove accumulated drift and obstructions from trestles, culverts, and bridges after each storm, calling for assistance, when needed.

128. During heavy storms or high water, whether by day or night, whereby tracks or structures are liable to be damaged, Foremen and such of their forces as they deem necessary, must be on duty. At such times, they must go over their sections to make sure that the track is safe, taking stop signals with them.

129. They must see that Watchmen are properly detailed to patrol the track, watch bridges, or perform other duties, whenever necessary, for the safety of track and structures.

130. They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of buildings, fences, telegraph poles, timber, or other material, and the spread of fires to adjoining property. They must not permit fires to be started unless they have sufficient force to keep them under control.

Fires discovered on adjoining property must be promptly extinguished, if possible, and a report of the damage and origin, if it can be ascertained, made on the prescribed form.

131. They must keep the ground under and near buildings, bridges and trestles cleared of vegetation and combustible matter. Where water barrels are in use, they must keep them filled with water. They must keep bridge seats, tops of piers, and other readily accessible portions of bridges and trestles free from cinders, dirt and vegetation.

132. They must keep interlocking pipe lines and trunking free from grass and weeds, and switches, frogs and movable parts of interlocking plants free from snow, ice, and other obstructions. They must give special attention to drainage through interlocking plants and where track circuits are used.

133. When track work is to be done which may disturb interlocking or signal apparatus, there shall be co-operation between the Section Foreman and the Signal Maintainer or Foreman.

134. They must give special attention to the maintenance of road crossings, both as to safety and quality of track and as to the safe and comfortable accommodation of the highway travel on the crossing and approaches.

135. They must not permit any encroachment upon the Company's property or occupancy of any portion of the Company's buildings or grounds without proper authority.

Extra or Floating Gang Foremen

136. Extra or Floating Gang Foremen, in charge of trackmen, report to and receive instructions from the Supervisor of Track.

137. They will have full charge of all forces under them, perform such duties and employ the number of men the Supervisor of Track directs.

Watchmen

138. Track, Bridge* and Tunnel Watchmen report to and receive instructions from the Section Foremen.

139. Track Watchmen must carefully examine the track and roadbed and see that they are in safe condition and that all switches are properly set and locked for the main track. They must examine buildings and other property of the Company and protect them from theft and fire. Should the track be obstructed, the Watchman must display stop signals in either direction from which trains may approach, and immediately notify the .... and the Section Foreman.

140. Bridge Watchmen must keep a supply of water or sand on the bridges at all times and be prepared to extinguish fires. They shall keep the coping of the abutments and piers clean, remove combustible materials from near the bridges and frequently examine the bridge and report any defects found. Should they observe any obstruction of a dangerous character, they must display stop signals in either direction from which trains may approach, and immediately notify the ....

141. Tunnel Watchmen must make frequent trips through the tunnels, observing the condition of the tracks, particularly the rails, and also observe the walls of the tunnel, removing in winter all icicles which may become dangerous to traffic. In case obstructions occur which would endanger trains, they must at once display stop signals in either direction from which trains may approach and immediately notify the ....

---

*Refers to watchmen patrolling bridges, not to structure watchmen.

142. When the time of Track, Bridge, or Tunnel Watchmen is not fully occupied with watching, they will perform such other duties as may be assigned them.

Supervisors of Bridges and Buildings

143. Supervisors of Bridges and Buildings report to and receive instructions from the Division Engineer.

144. They are in charge, on their respective districts, of the maintenance of bridges and structures, and of the employees engaged thereon.

145. They shall have immediate supervision of work train service for the maintenance of bridges and structures, using such service only when properly authorized by the Division Engineer.

146. Supervisors of Bridges and Buildings must make the prescribed inspections of the structures and appliances under their charge, and make the required reports.

147. They must know that the foreman and others under their supervision fully understand and properly perform their duties; keep account of and report their time in the manner prescribed and discipline them when necessary.

148. They must know that the foremen are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

149. They shall keep themselves informed in regard to all work performed, upon bridges and structures in their districts by contractors, or others, who may not be under their supervision; see that the work is done in such manner as not to endanger the safety of tracks, bridges or structures, and report promptly to the proper officer, if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

150. In case of damage to bridges or structures they shall promptly assemble men and material, proceed to the place of accident as quickly as possible, and make necessary repairs. They shall investigate all accidents to bridges and structures, and report promptly to the proper officer on the prescribed form.

151. They shall know that water barrel or sand box rests on all timber bridges and trestles are in repair and supplied with barrels and buckets, and that station and other structures are equipped with the necessary water barrels, buckets and other appliances for use in case of fire.

General Foremen

152. General Foremen in the Bridge and Building Department report to and receive instructions from the Supervisor of Bridges and Buildings. All rules for the guidance of Supervisors of Bridges and Buildings apply to General Foremen in that Department.

153. They will have charge, under the Supervisor of Bridges and Buildings, of all bridges and structures in their respective districts; will have general oversight of the work being performed on such bridges

and structures and will perform such other duties as may be assigned them by the Supervisor.

Bridge and Building Foremen

154. Bridge and Building Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

155. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on a bridge or structure which will interfere with the safety of trains, except under proper protection.

156. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs. They must see that these men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material, furnished them.

157. They will have charge of, and are responsible for such tools and material as are necessary for the performance of their work, and must know that these are properly used.

158. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

Mason Foremen

159. Mason Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

160. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on a bridge or structure which will interfere with the safety of trains, except under proper protection.

161. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs. They must see that these men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution, and use of material furnished them.

162. They will have charge of, and are responsible for, such tools and materials as are necessary for the performance of their work, and must know that the tools and material are properly used.

163. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials

Painter Foremen

164. Painter Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

165. They are responsible for the safe, proper, and economical performance of the work assigned to them. They must do no work on

bridges or structures which will interfere with the safety of trains except under proper protection.

166. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs They must see that their men properly perform their duties and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of material furnished them.

167. They will have charge of and are responsible for such tools and materials as are necessary for the performance of their work, and must know that these are properly used.

168. Painter Foremen must examine the rigging and exercise care in the erection of rigging and scaffolding, and must know that they are safe before permitting them to be used.

169. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

Water Station and Plumber Foremen

170. Water Station and Plumber Foremen report to and receive instructions from the Supervisor of Bridges and Buildings.

171. They are responsible for the safe, proper and economical performance of work assigned to them. They must do no work which will interfere with the safety of trains, except under proper protection

172. They will have full charge of all forces under them and shall employ such forces as the Supervisor of Bridges and Buildings directs They must see that their men properly perform their duties, and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men and of the receipt, distribution, and use of material furnished them.

173. They will have charge of and are responsible for such tools and materials as are necessary for the performance of their work, and must know that these are properly used.

174. They will have charge of and are responsible for the maintenance of water stations, pipe lines, tanks, water columns, heating plants, plumbing and piping and of the installation of boilers for such plants, when so directed. They shall report any abuse or improper operation of the machinery under their charge.

175. They shall know that duplicate parts of such plants in their charge as are subject to exceptional wear or liability to breakage are available at all times.

176. When assistance is necessary to make repairs to water supply units, request must be made on the Supervisor of Bridges and Buildings.

177. When necessary to take any water tank, water column or any facility affecting the operation of other departments out of service, either temporarily or permanently, the Foremen will notify the Supervisor of Bridges and Buildings and must not, except in emergency, proceed with the work until authority is obtained. If an emergency exists,

he shall notify the Superintendent, Division Engineer and Supervisor of Bridges and Buildings by wire. When the facility is restored to service, proper notice must be given.

178. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable materials.

Bridge Inspectors

179. Bridge Inspectors report to and receive instructions from the Supervisor of Bridges and Buildings.

180. They will be governed by the instructions for the inspection of bridges, as adopted by the A.R.E.A., and will conform to the instructions issued by the ....

181. They will perform such duties as may be assigned them by the Supervisor of Bridges and Buildings.

Supervisor of Signals

182. Supervisors of Signals report to and receive instructions from the Division Engineer.

183. They are in charge, on their respective districts, of the maintenance of all automatic and mechanical signals and plants and of the employees engaged thereon.

184. They must make frequent inspection of all signals and plants under their charge and make the required reports.

185. They must know that Foremen, Maintainers and others under their supervision fully understand and properly perform their duties; keep account of and report their time in the manner prescribed and discipline them when necessary.

186. They must know that Foremen and Maintainers are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

187. They shall keep themselves informed in regard to all work performed upon automatic and mechanical signals, plants and appliances in their districts by contractors and others, who may not be under their supervision; see that the work is done in such manner as not to endanger the proper operation of such signals, plants or appliances, and report promptly to the proper officer if the work is not done in accordance with plans and specifications, or according to prescribed standards.

188. In case of damage to automatic or mechanical signals, plants or appliances, they shall promptly assemble men and material, proceed to the place of accident as quickly as possible, and make the necessary repairs. They shall investigate all accidents to automatic and mechanical signals, plants and appliances, and report promptly on the prescribed form.

189. They must investigate failures or improper working of interlocking and signal apparatus, see that repairs are made promptly and make the prescribed reports.

190. They must know that signal apparatus is tested frequently in order, if possible, to discover defects or irregularities which might lead to failures.

191. They must not make or permit to be made any alterations or additions to the interlocking or signal apparatus without proper authority. Such authorized changes or additions as are made must be reported to the proper authority immediately upon their completion, so that the other departments affected may have such information.

Signal Foremen

192. Signal Foremen report to and receive instructions from the Supervisor of Signals.

193. They are responsible for the safe, proper and economical performance of the work assigned to them.

194. They will have full charge of such forces as the Supervisor of Signals directs. They must see that these men properly perform their duties and shall discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of material furnished them.

195. They will have charge of, and are responsible for such tools and materials as are necessary for the performance of their work, and must know that these are properly used.

196. When any part of an interlocking plant is to be repaired, an understanding must be reached with the signalman on duty, in order to insure safe movement of trains and engines during repairs. The signalman on duty must be notified when the repairs are completed.

197. Signal Foremen must notify the Supervisor of Signals, in advance of any work requiring the removal from service of any part of signal or interlocking apparatus, and such apparatus must not be taken out of service until proper authority is obtained.

198. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable material.

Signal Maintainers

199. Signal Maintainers report to and receive instructions from the Supervisor of Signals.

200. They are responsible for the safe condition and proper maintenance of the interlocking or signal apparatus in their territory and for the economical use of material in their maintenance.

201. They will have full charge of such forces as the Supervisor of Signals directs. They must see that these men properly perform their duties. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of the material furnished them.

202. When any part of an interlocking plant is to undergo repairs an understanding must be reached with the signalman on duty, in order

to insure safe movement of trains and engines during repairs. If it is necessary to disconnect any switch, movable point frog or derail, it must be securely spiked in proper position before permitting trains or engines to pass over it.

203. Signal Maintainers must notify the Supervisor of Signals before taking any signal or interlocking apparatus out of service, and authority must be obtained, except in emergency, before such apparatus is taken out of service. Should an emergency arise which requires removal from service of any apparatus, signals must display their most restrictive indication; switches, movable point frogs and derails must be securely spiked in correct position and Supervisor of Signals, Division Engineer and Superintendent immediately notified by wire.

204. In case of accident or serious damage to interlocking or signal apparatus in their territory, Signal Maintainers must immediately proceed to the place, asking for such assistance and material as may be required, and make repairs promptly.

205. If an accident is caused or alleged to have been caused by any defect in the interlocking or signal apparatus, a thorough examination must be made before any apparatus is disturbed; a record of the position of the levers shall be made, and a written statement of conditions found shall be sent to the Supervisor of Signals.

206. Signal Maintainers must co-operate with track forces in work pertaining to the maintenance of such track appliances as affect the operation of signals.

207. They must make such inspection and repairs of signal apparatus under their charge as will secure proper operation. They must inspect the signal lights on their territories at regular intervals and make report to the Supervisor of Signals.

208. They must make the usual standard tests for condition and efficiency of interlocking switches, derails, etc., keep them adjusted, and make the required reports.

General Foremen of Telegraph and Telephone (or Other Designated Officer)

209. General Foremen of Telegraph and Telephone (or other designated officer) shall be in charge, on their respective districts, of the maintenance of all telegraph and telephone lines and apparatus and of the employees engaged thereon.

210. They must make frequent inspection of all telegraph and telephone lines and apparatus under their charge and make the required reports.

211. They must know that Foremen, Maintainers and others under their supervision fully understand and properly perform their duties; keep account of, and report their time in the manner prescribed and discipline them when necessary.

212. They must know that Foremen and Maintainers are supplied with tools and material necessary for the efficient performance of their duties and that these are properly used.

213. They shall keep themselves informed in regard to all work performed upon telegraph and telephone lines and apparatus in their districts by contractors and others who may not be under their supervision; see that the work is done in such a way as not to endanger the proper operation of the telegraph and telephone lines and apparatus, and report promptly to the proper officer if the work is not being done in accordance with the plans and specifications or according to prescribed standards.

214. In case of damage to wires or apparatus, they shall promptly assemble men and material, proceed to the place of accident as quickly as possible, and make the necessary repairs. They shall investigate all accidents to wires and apparatus and report promptly to the proper officer on the prescribed forms.

215. They must investigate failures or improper working of telegraph or telephone apparatus, see that repairs are made promptly and make the prescribed reports.

216. They must know that telegraph and telephone wires and apparatus are tested frequently in order, if possible, to discover defects or irregularities which might lead to failures.

217. They must not make or permit to be made, and alterations or additions to the telegraph or telephone wires or apparatus without proper authority. Authorized additional changes or additions, when made, must be reported to the proper authority immediately upon their completion, so that the other departments affected may have such information.

Telegraph and Telephone Foremen

218. Telegraph and Telephone Foremen are responsible for the safe, proper and economical performance of the work assigned to them.

219. They will have full charge of such forces as may be assigned to them. They must see that these men properly perform their duties and discipline those who are incompetent or neglectful. They must keep the records and make the required reports of the time of their men and of the receipt, distribution and use of material furnished them.

220. They shall have charge of and are responsible for such tools and materials as are necessary for the performance of their work, and must know that these are properly used.

221. When any part of the telegraph or telephone apparatus, which affects the movement of trains, is to be repaired, an understanding must be reached with the Chief Despatcher or Wire Chief to insure safe movement of trains and engines during repairs. The same officer must be notified when the repairs are completed.

222. Telegraph and Telephone Foremen must notify their superior officer in advance of any work requiring the removal from service of any part of the telegraph or telephone wires or apparatus, and such apparatus must not be taken out of service until proper authority is obtained.

223. The completion of any work includes the cleaning of the premises, proper disposition of debris, and removal of usable material.

Telegraph and Telephone Maintainers

224. Telegraph and Telephone Maintainers are responsible for the safe condition and proper maintenance of the telegraph and telephone wires or apparatus in their respective territories and for the economical use of material in such maintenance.

225. They will have full charge of such forces as may be assigned to them. They must see that these men properly perform their duties. They must keep the records and make the required reports of the time of their men, and of the receipt, distribution and use of the material furnished them.

226. When any part of the telegraph or telephone wires or apparatus, which directly affects the movement of trains, is to undergo repairs, an understanding must be reached with the Chief Despatcher or Wire Chief in order to insure the safe movement of trains and engines during repairs.

227. Telegraph and Telephone Maintainers must notify their superior officer before taking out of service any part of the telegraph and telephone wires or apparatus, and authority must be obtained, except in emergency, before such wires or apparatus are taken out of service. Should an emergency arise, which requires the removal from service of any part of telegraph or telephone wires or apparatus, their superior officer must be immediately notified by wire.

228. In case of accident or serious damage to telegraph or telephone wires or apparatus in their territory, Telegraph and Telephone Maintainers must immediately proceed to the place, asking for such assistance and materials as may be required, and make every effort to restore the service promptly in order of importance.

229. Telegraph and Telephone Maintainers must make inspections, tests, and repairs of the telegraph and telephone wires and apparatus under their charge in accordance with prescribed rules and instructions.

Conduct of Work

Care of Right-of-Way

230. Section Foremen shall keep their sections in a neat and orderly condition, and shall devote sufficient time to cleaning and putting things in order around section toolhouses, station grounds, yards, sidings, highway and farm crossings, and the right-of-way generally.

Fencing

231. Section foremen are responsible for the proper inspection of the fences on their respective sections. They shall report to the Supervisor any defects found, making such temporary repairs as possible, and endeavoring to keep stock from getting upon the right-of-way or tracks, until permanent repairs can be made. They should endeavor to keep all gates closed, securing so far as possible the coöperation of the adjacent landowners in this effort.

Mowing

232. The amount of mowing done will depend upon local conditions and Federal, State or County laws or regulations. Where the railroad runs through forest lands, fire regulations must be complied with.

233. Section Foremen, under the direction of the Supervisor, are responsible for compliance with all the laws, rules and regulations in effect in their respective districts, with reference to mowing and fire protection.

General Cleaning

234. Section Foremen should for reasons of economy, as well as neatness, gather up scrap and usable material from the right-of-way, disposing of the same as directed by the Supervisor. They should see that no trees which by their location or condition might endanger trains or the telephone or telegraph wires, are left standing on the right-of-way or adjacent thereto, getting permission to cut those trees not on the right-of-way, if possible to do so. They should endeavor to keep the tracks and right-of-way in a neat and tidy condition.

Roadbed

Drainage

235. Thorough drainage of the roadbed is absolutely necessary before good track can be secured or maintained, and it is of the first importance that this matter be given careful detailed consideration at all points.

Surface Drainage

236. Ditches should be kept open at all times so as to divert the water from the roadbed quickly. They should be dug out thoroughly and restored to full size in the spring and late fall. Side ditches should be dug uniformly and parallel to the track, and conform to the standard roadbed sections.

237. Intercepting ditches should be constructed along the top of the bank, for the protection of cuts, where the drainage area would be likely to collect sufficient water during heavy rains, from the higher ground adjacent, to wash the slopes.

238. The end of a ditch should be diverted from the track, so that the scouring action of the water will not weaken or wash away the roadbed.

239. Waterways leading to and from bridges and culverts should be kept clean within the limits of railroad property. All culverts should be kept open for the free and unobstructed passage of water at all times.

240. In regions of heavy snows, ditches should be cut through the snow, wherever a sudden thaw would be likely to flood the track, and all ditches should be cleaned when the snow is melting in the spring.

241. Cross drains should be put in at proper intervals, where directed.

Underground Drainage

242. In wet or narrow cuts, where side ditches cannot be effectively maintained, sub-drains will be provided as directed by the ...., who will determine the size and character of drains to be used. Such drains must be laid to a true grade and in conformity with standard plans.

Care of Roadway

243. The cross-section of the roadway shall conform to the standard plans. No deviation from the sections shown shall be made without proper authority.

244. Growth of vegetation on the slopes of cuts and embankments should be encouraged to prevent erosion.

Track

Storage of Ties

245. Ties stored along the right-of-way should be piled to conform to the standard plan. (The standard plan should show the minimum distance to the nearest rail.)

246. Ties intended for treatment should not be inspected before being brought to the shipping point. As soon as such ties are brought to the shipping point by the producer, they should be inspected and loaded promptly for shipment to storage yards at treating plants.

Renewals—Inspection for

247. The ties in track must be inspected at stated times each year and those which will not last until the next inspection marked for renewal. This inspection should be made preferably by the Supervisor personally, accompanied by the Section Foreman. The Supervisor should report to the Division Engineer, on the proper form, the number of ties marked for renewal on each mile and each section. This report should be carefully checked by the Division Engineer and where any unusual or unfavorable condition is indicated, a thorough investigation should be made to insure proper renewals.

Renewals—Method of

248. The renewal of ties should be started when directed by the Division Engineer. All defective ties removed from track shall each day be placed for burning or loading on cars. The Supervisor shall frequently inspect ties removed from track to see if any have been removed which might have remained in the track, with safety, until the next inspection.

249. Ties shall be spaced according to the standard plan. All ties shall be placed square to the line of rails. The outside ends on double tracks, and the ends on one side throughout on single track, should be lined parallel with the rail.

250. Ties should be laid so as to obtain the best bearing. The

side nearest the heart of the tree should be placed down whenever possible. Twisted or badly hewn ties should have the bearings made true with an adze. It is good practice to adze ties requiring treatment before the preservative is applied.

Use of Tie Plugs

251. Whenever spikes are drawn from ties, wooden tie plugs should be driven into all holes, except in ties which are to be renewed that season. In replacing spikes, they should be driven into the plugs.

Records of

252. Full and accurate records of tie renewals and all data of value in connection therewith should be kept on suitable forms. Forms recommended by the A.R.E.A. are most convenient and satisfactory.

Rail Renewals

253. The most expensive and the most easily damaged part of the track structure is the rail, therefore care should be exercised in the unloading and handling of it. In unloading from cars, rails should be skidded or otherwise carefully lowered to prevent injury. Where it is necessary to drop them, both ends must be dropped at the same time, and the greatest care taken to avoid their falling on hard or uneven surfaces. Rails received in gondola cars should be unloaded with some approved device to prevent injury.

254. Rails should be distributed, as far as practicable, where they can be laid with the least amount of handling. Unless the rail is to be laid at once, it should not be distributed through yards and station grounds where trainmen and others may stumble over it.

255. Rail laying may be done in the winter months, or at such seasons of the year, depending on the climate, as are not favorable for doing other track work.

256. Where practicable, rail should be laid one at a time. Standard expansion shims should be used. The openings between 33 ft. rails should be as follows:

—20° to 0°	5/16 inch
0° to 25°	1/4 inch
25° to 50°	3/16 inch
50° to 75°	3/8 inch
75° to 100°	1/16 inch

Over 100° rail to be laid close.

Care should be taken that the openings between the rails be not more than the above limits, as too much expansion in the joints will spoil the rail quicker than any other error or defect in the method of laying, especially under heavy traffic.

257. Care should be exercised by those in charge of rail laying gangs to see that adzing is carefully done and the rail left in proper line, gage and surface. Shims should be used if the track is frozen and the ties cannot be lifted to eliminate low spots. It is desirable to place tie

plates and anticreepers the same day the rail is laid. It is especially important to prevent any running of the rail by using a sufficient number of anticreepers at once, as any running of the rail changes the expansion in the joints, making some joints wide and others close, resulting in battered joints, and in the hot weather danger from buckling of the track where the joints are tight.

258. Except for very sharp curves, sharper than are usually found in main line tracks, rail should not be curved before laying.

259. All kinked or crooked rails should be straightened before being laid; if surface bent, they must either be removed or straightened.

260. In making temporary connections in main tracks, an old rail should be cut and fastened to the new rail, using compromise joints when necessary.

261. When replacing rail of approximately the same width of base, so that the tie plates need not be changed, but two lines of spikes should be drawn. When a different tie plate is required, all spikes must be drawn. Where no tie plates are in use but three lines of spikes need be drawn for any change in the width of the base of rail.

262. All spikes should be driven vertically with the face in contact with the base of the rail. They should not be straightened while being driven. The rail must be full spiked, and the spikes should be staggered so that the outside spikes will be on the same side of the tie, and the inside spikes on the opposite side. Where shoulder tie plates are used, a third spike may be driven on the inside of the rail, with the back of the spike against the base of the rail. Good second-hand spikes can be used for the third spike.

263. All joint bars should be securely fastened with the full number of bolts. At permanent connections of rails of different sections, compromise joints should be used.

264. For the preservation of the rail, and to secure the best bearing for carrying the loads, and distributing the weight of the rolling stock uniformly over the rail and to the roadbed, the ties should be spaced a uniform distance, face to face. Approximately eleven (11) inches apart will give, with average ties, twenty (20) ties to a thirty-three (33) foot rail and eighteen (18) ties to a thirty (30) foot rail.

265. The rail joint should be so designed as to obviate any necessity for special spacing of the joint ties. With properly designed joints, respacing of ties when the rail is renewed is unnecessary.

Bonding

266. Where track circuits are used for operation of signals or other purposes, bonding of the rails is necessary and this feature should receive proper consideration and the work be carefully and efficiently performed. Where air, electricity or other power is available, any mechanical arrangement which will operate drilling machines successfully is desirable and economical.

Replacement—Inspection of Rail in Track

267. A complete record should be kept by miles and sections, of

the manufacturer, section, year, position and rail letter, of all new rail laid in track. This record should be kept in book form; one copy in the Division Engineer's office, one copy covering his section, by each Section Foreman. This record should be kept absolutely up to date, each and every change, whether of individual rails or many rails, being immediately recorded in the books and the old record removed.

268. Track walkers should be properly instructed to look for broken or defective rails, and report same, when discovered, to the Section Foreman, taking proper precautions to protect traffic, if necessary, on account of the condition of the rail found.

269. Where rail failures become numerous, especially if transverse fissures develop, a special rail inspection should be arranged. This can be facilitated by the use of a mirror attached to a short wire handle for examining the inside and underside of the head of the rail. A good magnifying glass with which minute defects or hair line cracks can be inspected, is desirable. This method of inspection, if properly conducted, will result in the discovery of a large percentage of transverse fissures before the rail breaks in the track, and such rails can be removed. When one rail of an ingot fails in track by reason of a transverse fissure, all the remaining rails of that ingot should be removed from main line passenger tracks. Such rails may be relaid in side tracks or in yards.

Broken Rails

270. A broken rail found in the main track must be protected immediately by a flagman and no trains allowed to pass over it until it is found that the rail is in such condition as will permit the train to pass in safety. If it is decided trains may pass over the rail safely, all trains must be stopped before reaching the break, and then allowed to proceed at slow speed. If a suitable rail is available, the broken rail should be replaced immediately; otherwise, if it can be done, the broken ends of the rail should be connected by joint bars, the rail drilled and the joint bars full bolted, after which the resumption of traffic may be permitted.

Joint Bars

271. The joints should be kept well oiled, both as a preservative from rust and to facilitate expansion and contraction of the rail.

272. Insulated joints should be installed only on rails conforming to the section for which they are designed. Care must be taken, when installing such joints, to properly place the insulation, and not to damage the fiber or bushings. The ties under and adjacent to insulated joints must be kept well tamped.

Track Bolts

273. As large track bolts should be used as the rail and joint bars will permit.

274. It is essential to the preservation of the rail and joint bars

that track bolts be kept tight. The use of proper nutlocks, keeping the bolts well oiled, and careful inspection and systematic tightening of all bolts is required of Section Foremen.

275. Track bolts should be gone over and re-tightened after new rail has been laid, as soon as traffic has worn the mill scale and rust off the joint bars and settled the bars into place.

276. Care should be exercised in the design of wrenches for tightening track bolts. The jaws should fit the nut as closely as possible and the handle should be long enough so one man can tighten the nuts, but not long enough so one man can twist or stretch the bolts.

Nutlocks

277. Spring nutlocks of approved design should be used on all track bolts.

Track Spikes

278. Care should be exercised in driving spikes to keep the spike vertical, so as not to necessitate straightening the spike by striking the back of the head with a hammer when it is partly driven. Spikes should be driven until the heads are in contact with the base of the rail, but not driven too far, thereby bending the neck and causing the head to crack or break off.

279. Badly bent, crooked, or neck-cut spikes should not be used, especially in main tracks. Good spikes, which are bent, should be sent to a reclaiming plant and straightened.

Anticreepers

280. Anticreepers should be applied where instructed by .... The number of anticreepers per rail will depend upon the physical characteristics of the track, and the amount and character of the traffic.

281. In the application of anticreepers care should be exercised to use proper tools, to properly apply the anticreepers, and not to damage any of their parts. The use of spikemauls, or heavy hammers, should be discouraged.

Tie Plates

282. Tie plates should be used where directed by the ....

283. Shoulder tie plates, so punched that special joint plates are unnecessary, should be used.

284. When applying tie plates care should be exercised to see that the plates have a full even bearing on the ties, that the track is in correct gage before they are spiked to the tie and that the shoulder of the plate rests against the base of the rail for the full width of the plate. The shoulder of the plate must not be permitted to remain under the base of the rail. Rough or crooked ties should be adzed when necessary to give a level bearing and all old spike holes should be plugged.

Ballast

Cross-Section

285. The cross-section of the ballast should conform to the standard plans.

Unloading

286. When unloading ballast care must be exercised to secure proper disposition and avoid waste. If special ballast cars are not available, hopper bottom cars should be used.

Ballasting

287. It is not possible to maintain good riding track under heavy traffic with insufficient ballast. The purpose of ballast is to provide a uniform support for the track, distribute the weight of the trainload to the roadbed, hold the track in position, and assist in the drainage.

288. Track must be kept in good line and surface while ballasting. The ballast program should be so arranged, and the supply so regulated, as to leave the least possible open track when the season closes. During the progress of the ballasting, open track should be watched carefully and protected with the prescribed slow signals, if necessary.

289. Where directed by the Division Engineer, preparatory to the distribution of new ballast, all the old ballast and unsuitable material will be removed to the bottom of the ties, for the full width of the roadbed, the old ballast cleaned, and the unsuitable material used for widening embankments or other purposes. At the same time, all ties requiring renewal should be replaced and the ties properly spaced, if necessary.

290. When the old ballast has been thoroughly cleaned, sufficient new ballast should be unloaded to make the first raise, which is usually made by shovel tamping the ties. When ballasting or surfacing track out of face, both rails should be raised together. It is safer, especially where traffic is heavy and fast, to raise both rails together, than to raise and surface one rail, and then bring the other rail up to grade.

291. Foremen should be sure they are properly protected by slow order, caution signs, or flag, or all of these, if necessary, when raising track, and should, except in emergency, raise against the current of traffic, where there is more than one track. A long easy runoff should always be prepared ahead of fast passenger trains.

292. In gravel or broken stone ballast, it is recommended as good practice to tamp the ties solid from 15 in. inside the rail out to the ends. If possible, the end of the tie outside of the rail should be tamped first and a train allowed to pass over before tamping on the inside of the rail. The space under the rail should be tamped well. The center of the tie should not be tamped.

293. Where the track is electricaly bonded, the ballast must be kept at least 1 in. below the base of rail. At road crossings, platforms, etc., where this is not practicable, the rails may be insulated by painting them

with an asphaltum or tar product, and good, clean stone mixed with the same material may be used for at least one foot each side of the rails.

294. The following tools should be used: For broken stone or furnace slag ballast: Shovel, tamping pick and stone fork. For gravel, chats, chert or cinder ballast: Shovel, tamping pick or tamping bar.

295. Mechanical tie tampers have been developed, which are efficient and economical, and these may be used for heavy main line work in any kind of ballast.

296. There are a number of devices and machines now being manufactured for use in cleaning ballast, and any device which is efficient and economical should be used.

Line and Surface

297. Good line and surface are the first essentials for good riding track. If sufficient ballast is furnished at the proper time and properly distributed, and tie renewals are kept up to date, the proper attention to line and surface will insure good riding track.

298. As early in the spring as the weather and track conditions will permit, the entire section should be gone over and smoothed up. At this time special attention should be given to those portions of the section on which no tie renewals or ballasting is expected to be done, during the season, and this track put in 100 per cent. condition. Where tie renewals are to be made, or ballasting is to be done, no unnecessary work should be done, the aim being to keep these portions of the section sufficiently smooth for safe and comfortable riding, until the work of renewing ties or ballasting can be accomplished.

299. Where the track shows evidence of being badly out of line on curves, and there is opportunity to do so, it is recommended that line stakes be set by Engineers. But ordinarily the Section Foreman, assisted, if necessary, by the Supervisor, can line the track very accurately and secure practically perfect riding curves by the use of a string.

300. By using a string 62 ft. long, holding the ends against the gage side of the high rail and measuring the distance from the middle of the string to the gage of the rail, the approximate degree of curve can be found—each inch of distance representing 1 deg. of curve.

301. When raising or surfacing track, Foremen must not trust to their eyesight alone, but must use the track level boards and sighting boards. Track level boards must be tested frequently.

302. When not surfacing out of face, as in case of picking up joints or other low places, the general level of the track should not be disturbed.

Shimming

303. Wooden shims placed under the rails should be used to maintain the proper surface of the track, when the surface is disturbed by the action of frost, or when other conditions make tamping impracticable.

304. When shimming, the track level and track gage must always be used.

305. Shimming should be done on top of the tie. No shimming

should be done under the tie, except in emergency and shims so placed should be removed as soon as possible.

306. Shims must be the same thickness throughout, and not wedge shaped. They must have an even bearing on the tie.

307. Where shims are used the rails must be securely braced to prevent spreading. Tie plates with one end placed against the outside under the head of the rail, and the other end spiked to the tie make good braces.

308. Section Foremen must watch track which has been shimmed very closely, testing frequently with the gage and level board to make sure that shims are in place and tight and that track does not get out of gage or surface.

309. When the frost is leaving the track, shims must be changed frequently replacing thick shims with thinner, until the necessity for shims has passed. As soon as the frost is entirely out of the track, all shims should be removed and the track surfaced, if necessary. Care should be exercised, however, that track surfacing is not done before the frost has all gone.

Gaging

310. Uniform gage is essential to good track and must be maintained.

311. The standard gage is 4 ft. 8½ in. Curves of 8 deg. and under should be standard gage. Gage should be widened ⅛-in. for each 2 deg. or fraction thereof, over 8 deg., to a maximum of 4 ft. 9¼ in. for tracks of standard gage. Gage, including widening due to wear, should never exceed 4 ft. 9½ in.

312. The installation of frogs on the inside of curves is to be avoided whenever practicable. Where this is unavoidable the gage of the track at the frog should be standard.

313. Where track is lined and surfaced the gage should always be checked and made standard at the same time. If the track is allowed to remain out of line or out of surface for any length of time, bad gage is very likely to result therefrom, and for this reason Foremen should always check the gage and make any necessary corrections when lining and surfacing the track.

314. Track gages should be checked frequently with a standard gage to assure that all gages are correct. This may be done each year in the winter months, and the gages should be painted a new standard color each time tested.

Elevation of Curves and Easements at Ends of Same

315. The elevation on curves and the easements at the ends of same should be in accordance with the requirements and according to prescribed standards.

316. Where the maximum speed allowed by timetable is higher than the maximum standard elevation will safely permit, the speed should be reduced accordingly. Signs should be placed at the beginning of each curve where the speed must be reduced below the maximum allowed by

the timetable. The signs should show in plain figures the maximum permissible speed.

317. The maximum elevation on any curve must not exceed seven and one-half inches. It should be remembered that speed is the principal factor in elevation on curves, and that the degree is a secondary factor only. Foremen should be cautioned not to carry too much elevation where speed is slow, even if the curvature is sharp. Where there is considerable freight traffic and passenger traffic is not so important, it is advisable to keep the elevation low on the curves, and slow down the passenger trains to meet the conditions.

318. Where possible, posts should be placed at the side of the track for the guidance of Section Foremen. These posts, indicating the elevation in inches and fractions thereof, should be set at the beginning of the easement; at the beginning and end of the regular curve, and at the end of the easement or point of the tangent. Posts should also be set at the points of compound and at each end of easements, between compound curves.

Frogs and Switches

319. The proper installation and maintenance of frogs and switches is essential both for safety and economy.

320. It is especially important to keep the track in good line and surface through frogs and switches, and Foremen must give these features special attention.

321. Switches and frogs must be inspected frequently to see that they are in proper working order, and that all nuts, bolts and other fastenings are in place and properly tightened. Any broken or damaged parts should be replaced promptly.

322. Switch points must fit closely and accurately to the stock rail, which must be bent in accordance with the prescribed standards. When renewing a switch point, the stock rail should also be renewed, if necessary to secure a proper fit of the point. In like manner a new stock rail should not be used with a worn point, as there is grave danger of derailment, if the stock rail is higher than the switch point.

323. Frogs must be protected by guard rails, constructed and placed in accordance with standard plans. The tops of the guard rails should be level with the main running rails, and should be securely held in place.

324. Guard rails should be so placed that the gage distance from the frog point to the flangeway side of the guard rail will be at least 4 ft. 6¾ in., and the distance between the flangeway sides of the wing rail and guard rail shall not exceed 4 ft. 5 in.

325. Switch rod and connecting rod bolts must be equipped with cotter pins. The bolts should be inserted with the nut on top for convenient inspection.

326. Switches must be kept free from obstructions at all times and free from ice and snow in winter. The slide plates should be kept well oiled.

327. Switch stands must be kept firmly spiked to the head-block ties, must be set plumb, and with the target square with the track.

328. Automatic switch stands should be inspected frequently for lost motion. They must be kept well oiled. Head-block ties must be kept firmly tamped.

329. The switch stand should be placed, wherever possible, on the side of the track where the connecting rod will be in tension when the switch is set for the main track. The switch banners and lamps should be placed on the right hand or engineer's side of the track approaching facing point switches.

330. All switch stands and facing point switches on multiple tracks and all main track switches on single track should be equipped with switch lamps of approved design, which will show the proceed color when the switch is set for the main track and the stop color when the switch is open.

331. Unless otherwise provided for, the Section Foreman is responsible for the proper care and maintenance of switch stands and lamps and must give these devices careful attention. Switch stands must be kept tight on the head-blocks and adjusted to give the switch the proper throw and to keep the points tightly against the rails, when the switch is closed, either for the main track or the turnout.

332. Switch lamps must be kept clean, supplied with oil, properly adjusted, and firmly placed on the switch stand, so they will not jar out when the switch is used.

333. Main track switches, not interlocked, must be kept locked at all times except when in actual use by trains, or when being inspected. Foremen must report immediately main track switches found unlocked or with the lock missing.

Switch Ties

334. Switch ties should be used for all permanent turnouts, cross-overs and railroad crossings, and should conform to the standard specifications for material, sizes and workmanship. They should be placed in track in accordance with the standard plans.

335. For temporary work, track ties may be used, lapping them in place of switch ties, but switch ties should be used for head-blocks and for at least three or four ties under the frog and guard rails.

Track Signs and Posts

336. Track signs and posts must be provided and placed in accordance with standard plans and special instructions.

337. Section Foremen must see that all track signs and posts are in their proper places and are kept plumb, and that weeds and other vegetation are not permitted to obstruct the view of same.

338. All track signs and posts, so far as possible, should be made of metal or other suitable material which will not quickly deteriorate. If made of metal, the posts of small signs can be made of old boiler flues, which have been scrapped. All track signs and posts should be kept painted.

Road Crossings

339. Section Foremen are responsible on their respective sections for the proper care and maintenance of public and private road crossings.

340. Road crossings should be constructed and maintained according to standards, and conform to legal requirements. Plankless crossings are more easily maintained and more satisfactory to travelers on the highways. These are constructed of clean stone, of the smaller sizes used for road construction, with a good asphaltum binder for the top coat.

341. Road crossing signs where required by law, must be maintained. Such signs should be properly placed and kept clear of obstructions which would interfere with the view of travelers on the highway. Where possible, the permission of adjacent landowners should be secured, if necessary, and all brush or trees, obscuring the view of approaching trains, removed.

Track Tools

342. A sufficient number of the proper kind of tools, in serviceable condition, is essential for economy and efficiency in the performance of any kind of track work.

343. All track tools are furnished by and remain the property of the Company.

344. Section and other Foremen in charge of men will be held responsible for the proper care and use of tools. They must know that they have at all times a sufficient supply, in serviceable condition. They should see that tools are not lost or broken, and that, when not in use, they are not left where they are liable to be struck by trains or derail trains.

345. When not in use, all tools should be collected and properly protected from the weather and from being stolen. Where it is not practicable for Foremen to take all tools to the toolhouse each evening, suitable tool boxes, equipped with substantial locks, should be provided, and all tools placed therein each night.

346. Labor saving devices and appliances should be used wherever such use can be shown to be economical.

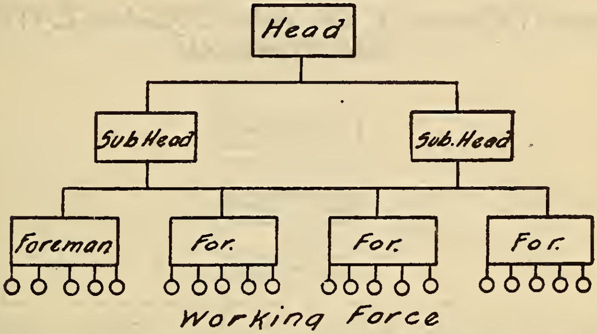
347. The use of heavy sections of rail makes the handling and laying of such by hand, laborious and costly. Rail handling and laying machines, or locomotive cranes, should be used for such work where available.

[3]THE SCIENCE OF ORGANIZATION

Up to the present, Organization has developed as an art rather than a science and has brought out two general types, viz., the *Line* Type and the *Staff* Type.

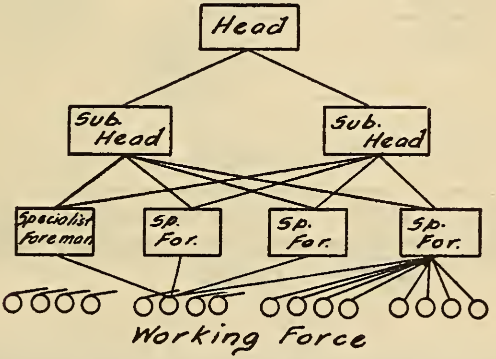
Line Type is exemplified in the army, in which there is a direct connection from the head through each subordinate to the next lower until the worker, if we may so call him, is reached.

Line Type



Staff Type is exemplified in manufacturing concerns, where there are specialists who may direct the worker in any part of his work that may be of a nature to be covered by the specialist's knowledge or authority.

Staff Type

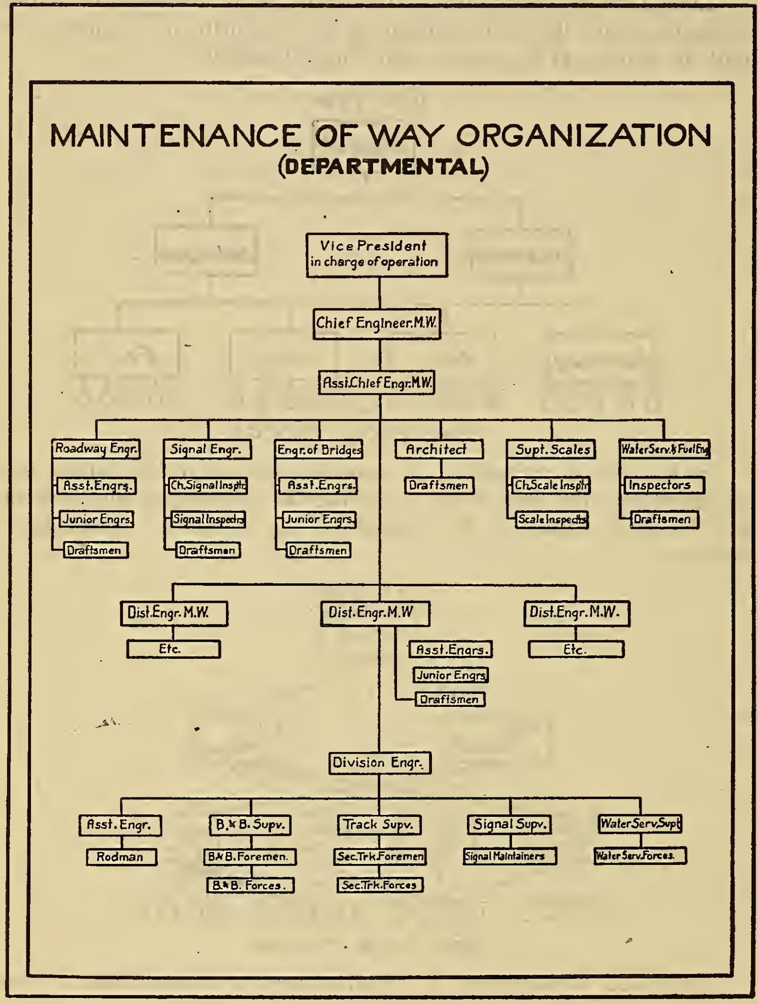


Nearly all organizations are combinations or modifications of these two types.

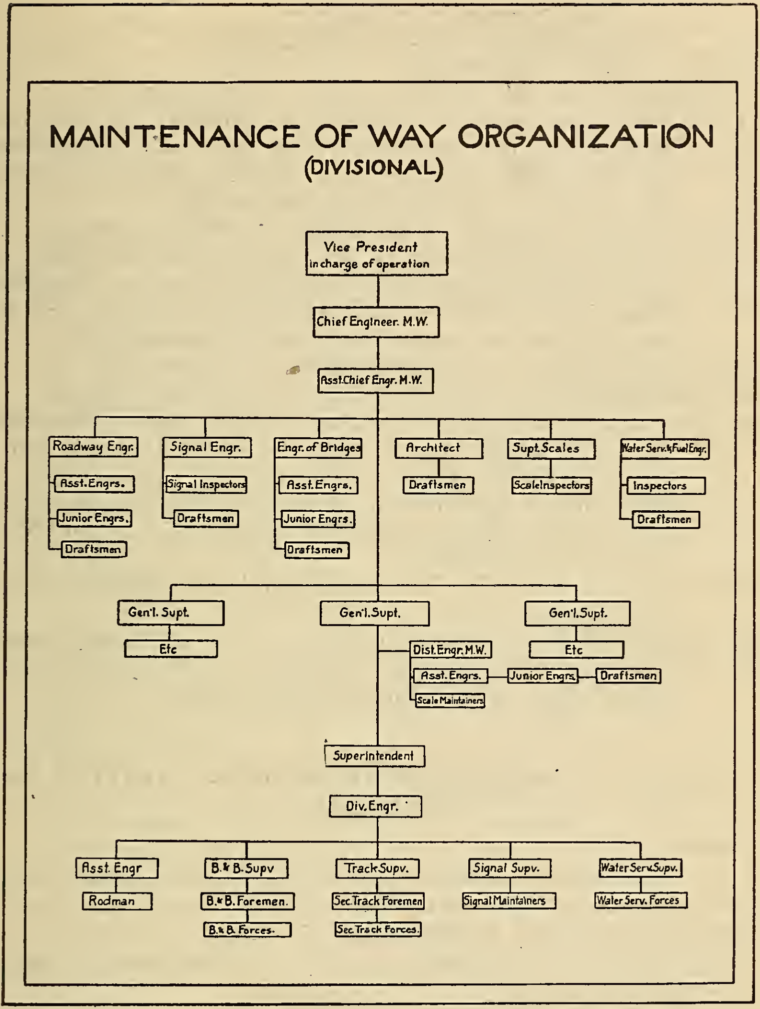
In the Organization of the Engineering forces of a railroad the types work out into what is known as Departmental and Divisional Organizations, which are modified Line Types, in the manner shown in the diagrams on following pages.

---

[3] Adopted, Vol. 22, 1921, pp. 838, 1082.



MAINTENANCE OF WAY ORGANIZATION
(DEPARTMENTAL)



Fundamentals of Organization

1. An organization must have its object clearly defined.
2. In its simplest form organization consists of Head and Working Force.
3. Subdivisions, combinations, extensions and modifications of this form may be made to any extent and may be most readily shown and understood by means of charts.
4. The Head or Executive must
    (a) understand his objective.

   (b) plan and direct all activities.
   (c) select and educate working force.
   (d) receive results.

5. Executive must have complete authority over working force.
6. Executive may subdivide or delegate his authority, in which case each subhead must know exactly his duties and responsibilities and there must be an invariable sequence without any conflict in, nor division of, authority and responsibility.
7. There must be harmony in all relations of different subheads.
8. There must be interchange of ideas and information between all types of executives and with the rank and file, as far as possible.
9. Working force consists of equipment, tools and men, and the economic relations between these must be balanced.
10. Correct discipline is an essential feature of organization.
11. Compensation must follow the human effort in just proportion.
12. Not only physical force is available in any human organization but proper results from 10, 11 and 4c should develop in such a body an *esprit de corps.*
13. Coördination and correlation of work as to time, place and materials must not only be planned by executive, but he must know that it is accomplished.
14. Subheads in the smaller spheres must apply all principles used by the higher executives.
15. Standardization of methods and means must be intelligently applied.
16. Organization charts give the simplest and most readily comprehended means of expressing the system in use.

[4] RULES FOR INSPECTION OF BRIDGES, TRESTLES AND CULVERTS.

General.

1. The inspection and maintenance of all bridges, trestles and culverts will be under the direct supervision of............ (Title) ...., who will be responsible for their safety.

2. The.............. (Title)..................shall personally inspect every structure at least...............each year.

3. One or more competent bridge inspectors who are familiar with strength of wooden structures and have a general knowledge of steel, stone and concrete work will be assigned for the inspection of bridges under the direct supervision of the.......................................

4. These bridge inspectors shall forward to the.......(Title)....... ....in (duplicate) (triplicate)............on the proper form provided, a report of each bridge, trestle or culvert inspected, enumerating in detail the parts of each structure inspected, giving the conditions found in each individual part. One of these forms must be

---

[4] Adopted, Vol. 21, 1920, pp. 469, 1440.

forwarded for each structure inspected, and shall be complete in itself, showing the actual conditions as found, regardless of what may have previously been reported. These reports must be forwarded at the end of each day's inspection.

5. The..................... (Title)......................shall examine these inspection reports, and if any defects of a serious nature are reported he shall take immediate steps to make the necessary repairs. After the...................... (Title)......................examines the inspection reports he will forward one copy of each of the bridge inspection reports to his superior officer, calling particular attention to any defects which are not of an emergency nature but are serious enough to warrant the attention of such officer.

6. The................ (Title)................shall make a personal inspection of each bridge, trestle or culvert at least once each year. He shall examine the inspection reports forwarded him by the...............
................................., keeping his immediate superior officer promptly informed of any defects discovered which require attention. He shall make recommendations to his superior officer with a plan, if necessary, to cover the work to be done to remedy various conditions or to make permanent improvements. He shall furnish annually a report to his immediate superior officer showing the condition of each bridge, trestle or culvert on his division.

7. The............. (Title)............and his subordinates should be thoroughly familiar with the capacity and stability of all of the bridge structures, trestles and culverts under their immediate charge. If any serious defects should develop which, in his opinion, would serve to weaken the structure of any member, he shall immediately report to his superior officer after personal inspection with his....................
..........................., giving recommendations to remedy the defects. He might request, if necessary, that a special inspection be made of the structure by a representative of the Engineer of Bridges.

8. At least once a year a general inspection of all bridges and structures shall be made by the head of the department or his representative, who is directly responsible for the maintenance of these structures. From this inspection, a program of all work which will be necessary during the ensuing year, in order to maintain the structures in safe condition, will be prepared. This inspection will afford all officers in direct charge of this character of work an opportunity to familiarize themselves with the detail work to be done during the next season.

9. No altering of span lengths, reinforcing (except of a temporary nature) or change of any bridge, trestle or culvert is to be made without authority being first obtained from the Engineer of Bridges through the proper officer.

Field Inspection.

10. Division Bridge Inspectors will report to and receive instructions from................. (Title) .... In the selection of the inspector, particular attention should be given to his judgment, activity and familiarity with the character of structures on the territory to

which he is to be assigned. It shall be the duty of the Division Bridge Inspector to inspect all bridges, trestles, culverts and other openings of whatever character on his territory.

11. The Division Bridge Inspector shall each day, after a structure is inspected, send to the................(Title)........................ a report on approved form in (duplicate) (triplicate) showing defects, if any, giving a minute description of said defects. Every part of both the super- and sub-structure (foundation and bridge) must be closely examined in detail. When no defects are found the report shall state—"Bridge in good condition. No defects found." A report for each separate structure inspected must be made each day, and each report must be complete in itself, and must show the actual condition of the structure as found, regardless of what has been previously reported. When defects are found which are of such a character as in the opinion of the inspector endanger traffic at regular speed, trains must be flagged and only allowed to pass over the structures at such speed as the inspector may consider safe.

Immediately after the inspector has taken steps to protect traffic, he must notify at the nearest telegraph or telephone station the Train Dispatcher with copy to the................. (Title) ...., and Superintendent, giving necessary information briefly as to safe speed of trains over the structure until permanent repairs are made. He shall follow this immediately with a written report on the next train to the ....(Title) ...., giving in detail the defects found. The............... (Title) ....upon receiving reports from the Division Bridge Inspector, after carefully going over same, shall forward one copy to the................ (Title) .... In the ....(Title)................office there should be provided a card index file upon which should be entered, periodically, the reports of the Division Bridge Inspector.

12. In order to reduce the amount of detail work in writing up these reports the following abbreviations are permissible in order to condense the report without destroying its effectiveness:

A.	Anchor
B.	Bottom
B. W.	Back wall
B. S.	Bridge seat
Bkt.	Bracket
Bm.	Beam
Con.	Connection
Cov.	Cover
Diag.	Diagonal
Diaph.	Diaphragm
E.	End
E. end	East end
W. end	West end
E. B.	Eastbound
Ex.	Expansion
F.	Floor
Fill.	Filler
Flng.	Flange
Fnd.	Foundation
Frm.	Frame
G. R.	Guard rail
Gen. Con	General Cond.
Gir.	Girder
Gus.	Gusset
Hor.	Horizontal
I.	Intermediate
In.	Inner
Ins.	Inside
L.	Angle
Lat.	Lateral
Mas.	Masonry
O.	Outer
Outs.	Outside
P.	Post
Packin.	Packing
Ped.	Pedestal
Pl.	Plate
Ptl.	Portal

Rd.	Rod
Rlr.	Roller
S. Pl.	Sole plate
Spl.	Splice
Stiff.	Stiffener
Str.	Stringer
T.	Top
U. C.	Undercoping
W.	West
W. B.	Westbound
W. W.	Wing wall
X.	Cross

Wooden Structures.

13. The inspection of foundations and masonry by the Division Bridge Inspector shall include the following:

Examine each arch, abutment, pier and their foundations, bridge seats and pedestals. Report any new cracks, settlements or increase of old defects, scouring around foundations or change in channel of stream. Special attention should be given to all work of this character, where any defects have been previously found and no action taken to remedy same. The attention of track foremen should be called to the importance of cleaning the bridge seats, the superstructure, channels, weeds and vines from the masonry and the removal of grass and weeds in and around the bents as well as all wooden trestles and structures. The Division Bridge Inspector should note such conditions on his report, and show the action taken in order to correct same. The Division Bridge Inspector must see that all bridge seats and cap stones of pedestals are properly set, reporting any movement or cracking of same.

14. The Division Bridge Inspector shall report and examine in detail the track approaches to all bridges and trestles to see that same are maintained in good line and surface, fully ballasted and that the rails on open deck structures are spiked in accordance with standard instructions, and that there is a full bearing on each tie. The Division Bridge Inspector shall inspect all joint fastenings and connections to see that they are in good condition, giving particular attention to see that standards are fully complied with where decks of ties are renewed out of face. He shall also see that the inside guard rail is placed on the structure in accordance with standards. He shall examine all ties and guard timber on open deck bridges for soundness. He shall see that the ties hold the spikes firmly; that all bolts are tight; that no guard rail or bolt ends in guard rail project above the level of the top of running rail a greater distance than 1 inch.

15. The Division Bridge Inspector shall make inspection of all timber in wooden structures, trestles and timber trusses, boring in same where necessary in order to determine interior decay. He shall examine chords closely at splices and all stringers at bearing points. He shall examine diagonal and vertical posts and laterals to see that they are truly in place, straight and sound and shall pay particular attention to any crushing at the ends. He shall examine all angle blocks, main and laterals, reporting if broken or cracked. He shall examine gib plates, noting particularly their bearing on the timber. He shall examine all rods to see that they are in proper adjustment and pay particular attention to every other part of the structure in detail not mentioned above. When adjustment of any member is necessary it must be done under the

personal supervision of the..................or his representative. The Division Bridge Inspector must report any odd size timbers, or span lengths of timber stringers in wooden structures or trestles which are not according to the standards, and shall report if any new work is not done in accordance with standards. The Division Bridge Inspector shall see that all timber bents are plumb and have transverse bracing, and in case of high trestles, particular attention must be paid to the longitudinal bracing and any deviation from the standard plan must be immediately reported.

Steel Structures.

16. The Division Bridge Inspector shall inspect all iron and steel work in metal structures and shall see that the steel is cleaned free from rust and that no water pockets are formed at the panel points. He shall examine every part to see that it is in true line, uninjured and in proper adjustment. He shall examine the line of girders to see it is correct and that the girders are setting plumb on the pedestals, masonry or bridge seat. He shall examine the bed plates, rollers and their frames to see that they are true and level and in proper working order. He shall see that all trusses and girders have a uniform bearing on the rollers, bed plates or pedestals. He shall examine all rivets to see that none are loose, reporting all loose rivets, giving their location by bridge number and the number loose in each. It shall not be required that all rivets be tested more than..............................each year, except in certain members where the rivets are especially liable to become loose. Examinations of such members should be made at least once every ....months. The Division Bridge Inspector shall give particular attention to any member which shows evidence of wear by becoming loose, rattling or rusting. To this end he shall give particular attention to all web members of trusses, lateral bracing, floor beams and stringer connections, yokes or hangers and connections at pins. He shall observe the action of the structure under trains operating over same at scheduled speed. He shall note any tension member which becomes slack, or any buckling which may occur in compression members. He shall note any perceptible yielding of the floor beams or stringers, or any perceptible side motion of the structure or any excessive deflection under traffic.

The Division Bridge Inspector shall pay particular attention to the details of metal structures as outlined above when the alinement is a curve. He shall look for loose rivets in all angles, especially in floor beams and stringer connections. He shall examine the steel for cracks at the root of all angles and web plates of girders, floor beams and stringers. He shall examine top and bottom cover plates and angles, flange angles of deck girders and floor system of through girders and trusses for deterioration from rust and other causes. He shall carefully examine all bearings where girders rest on pile, on frame bents, posts or towers, and shall see that the girders have a full and true bearing and are firmly anchored.

Masonry and Composite Structures.

17. The Division Bridge Inspector shall examine all masonry, concrete and composite structures for development of cracks or defects in abutments or piers. He shall examine deck for development of new cracks in masonry, pulling away of deck from piers or abutments. He shall examine underpart of ballast deck for cracking of concrete from reinforcement and shall report deterioration of reinforcement where exposed. He shall also report on failure of waterproofing of deck, causing a cracking of underconcrete protection of the steel structure.

Culverts and Pipes.

18. The Division Bridge Inspector shall examine all culvert and pipe openings to see that same are in good condition; that the sections of pipe are not pulling apart, and that they are kept cleaned at all times, so as to maintain full waterway and there is no undercutting at ends. He shall carefully examine walls and roof of masonry culverts, to see that no cracks are developing and roof is being properly maintained.

Records.

19. The ...(Title).... shall keep in his office an up to date cabinet and card filing system upon which shall be entered the reports of the Division Bridge Inspectors. This card index system should have guide cards for each individual bridge, using separate color for bridges and structures requiring special attention. A particular designation may be used for any weak structures which must be carefully watched. Guide cards should contain the following information:

Bridge number.
Mile post.
First station east of bridge.
Total length of bridge.
Number of spans.
Length of each span.
Maximum height, base of rail to water or road.
Kind or style of structure.
Date built.
Clearance of bridge over railroad or highway.

Back of each guide card should be filed sufficient blank cards for copying the reports of the Division Bridge Inspectors. In making a record of the bridge inspection reports of the Division Bridge Inspector the date of the report should be shown, followed by the details. Sketches showing proper names of the various members of through trusses, through girders and deck girders should be furnished all Division Bridge Inspectors and ....(Title)...., who should familiarize themselves with the standard terms and use these terms in preparing their reports.

20. The ....(Title)....... shall make frequent inspection of his card index so as to familiarize himself with the condition of the structures under his charge, and to see that the index is kept up to date.

21. The ...... (Title)....... shall make written report to his superior officer each month on form provided. Information on the prescribed

form should be compiled from Division Bridge Inspectors' reports and form should indicate action taken or recommendation made to remedy defects.

Forms.

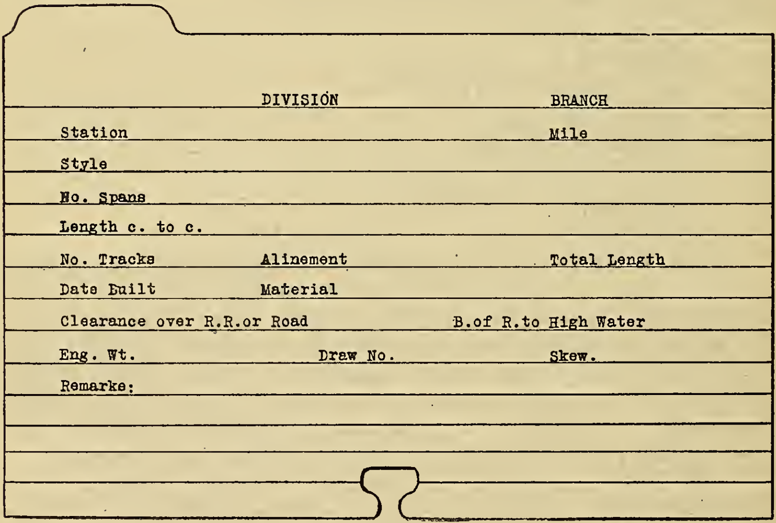
22. On succeeding pages are shown forms recommended for use of

(1) Division Bridge Inspector.
(2) ...... (Title) ....Periodical report to his superior officer.
(3) Card Record in........ (Title) ....Office.
(4) Designation (and abbreviations therefor) of several members of steel structures.

23. Of the forms for Division Bridge Inspector's use three specimens are shown. The general principles of these are the same, in that they should be printed in books of 100 or more leaves, each perforated with carbonized backs, with stiff cardboard or linen backs of a size not exceeding 4½" x 6½".

24. The forms for card index in .... (Title).... office should be similar to samples of any standard manufacture. Two colors should be used for guide cards, while file cards can be ruled or unruled.

25. ....Periodical report of bridge inspection to his superior officer should preferably be correspondence size with no ruled cross lines.



DIVISION BRANCH
Station Mile
Style
No. Spans
Length c. to c.
No. Tracks Alinement Total Length
Date Built Material
Clearance over R.R.or Road B.of R.to High Water
Eng. Wt. Draw No. Skew.
Remarks:

(Name of Railroad)

DAILY BRIDGE INSPECTION REPORT

__________________Division Bridge No.________________

Date ______________________

Present Condition of Structure

Work Required to Maintain Structure
in Good Condition

Following Work Must Be Done to Keep
Structure Safe

(Name of Railroad)

DAILY BRIDGE INSPECTION REPORT

________________Division Bridge No.________________

Date ____________________

Deck	
Paint	
Steel	
Rivets	
Pier and Abutment	
Substructure	
Work Required to keep Structure in Good Condition	
Work Required to keep Structure Safe	

(Name of Railroad)

DAILY BRIDGE INSPECTION REPORT

__________Division Bridge No.__________

Date__________

Condition of Structure

Deck

Stringers

Caps

Bents

Girder

Truss

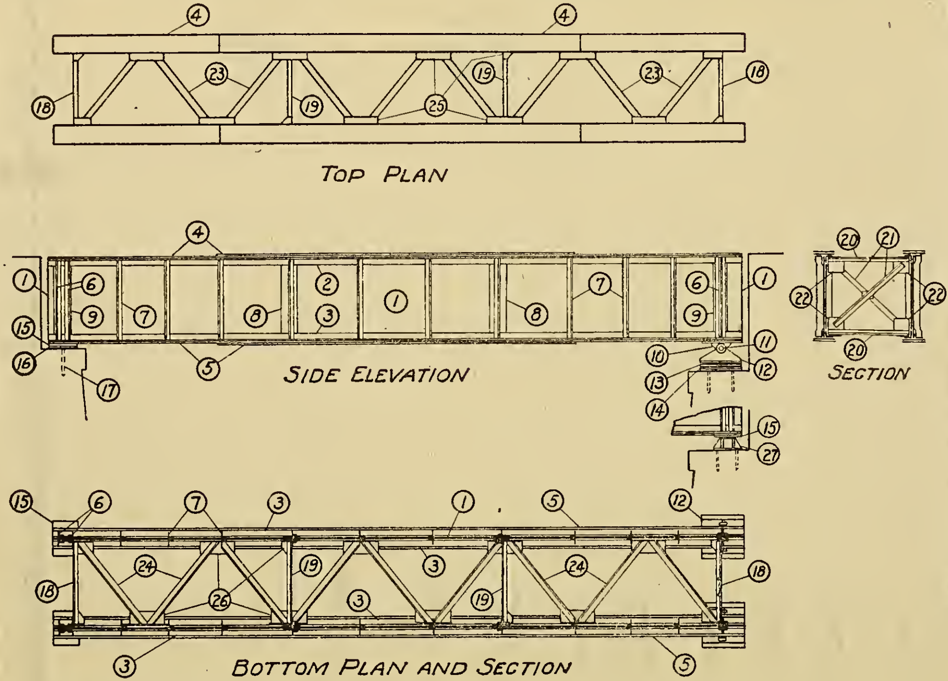
Masonry

Paint

Repairs

Future

Immediate



TOP PLAN

SIDE ELEVATION

SECTION

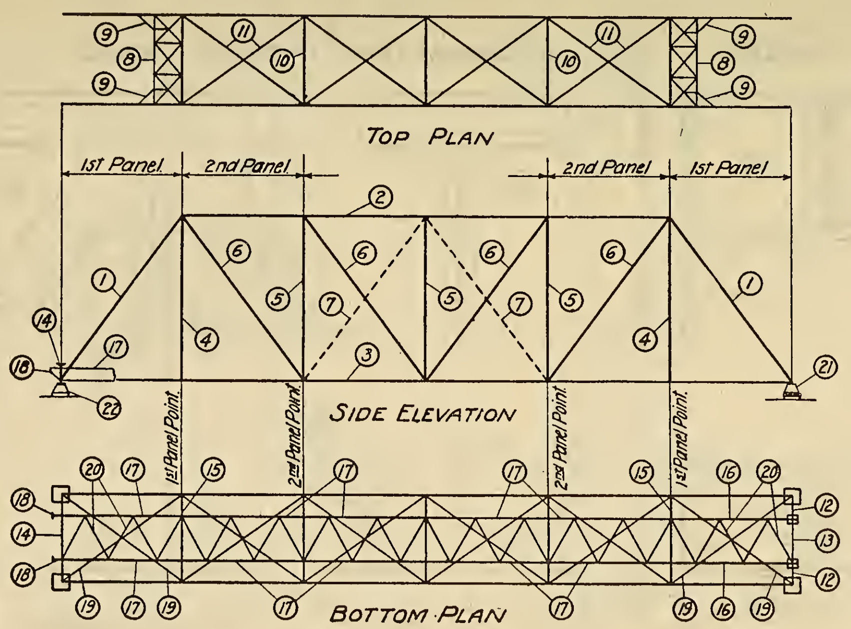
BOTTOM PLAN AND SECTION

Note.-Where sufficient information cannot be given by description furnish sketch.

LEGEND

No	Description	Location of Individual Members.
1	Web Pl.	Number from E. or W. End, N. or S. Gir.
2	T. Flng. L.	Inside or Outside, N. or S. Gir.
3	B. Flng. L.	Inside or Outside, N. or S. Gir.
4	T. Cov. Pl.	Number from Flng. L's, N. or S. Gir.
5	B. Cov. Pl.	Number from Flng. L's, N. or S. Gir.
6	E. Stiff. L.	Number from E. or W. End, Ins. or Outs, N. or S. Gir.
7	I. Stiff. L.	Number from E. or W. End, Ins. or Outs, N. or S. Gir.
8	Web Spl. Pl.	Number from E. or W. End, Ins. or Outs, N. or S. Gir.
9	Fill.	State Stiff. under which Fill occurs.
10	T. Pin Shoe.	E. or W. End, N. or S. Gir.
11	Pin.	E. or W. End, N. or S. Gir.
12	B. Pin Shoe.	E. or W. End, N. or S. Gir., Fix. or Exp. End.
13	Rlr. Nest.	E. or W. End, N. or S. Gir.
14	Rlr. Bed Pl.	E. or W. End, N. or S. Gir.
15	S. Pl.	E. or W. End, N. or S. Gir.
16	Mas. Pl.	E. or W. End, N. or S. Gir.
17	A. Bolts.	
18	E. X. Frm.	E. or W. End.
19	I. X. Frm.	Number from E. or W. End.
20	Hor. X. Frm. L.	State X. Frm. in which L occurs, T. or B.
21	Diag. X. Frm. L.	State X. Frm. in which L occurs.
22	Gus. Pl.	State X. Frm. in which Pl. occurs, T. or B., N. or S. Gir.
23	T. Lat. L. or Rd.	Number from E. or W. End.
24	B. Lat. L. or Rd.	Number from E. or W. End.
25	T. Lat. Pl.	Number from E. or W. End. N. or S. Gir.
26	B. Lat. Pl.	Number from E. or W. End. N. or S. Gir.
27	Shoe	E. or W. End, N. or S. Gir.

NAMES OF MEMBERS IN DECK PLATE GIRDER SPANS.

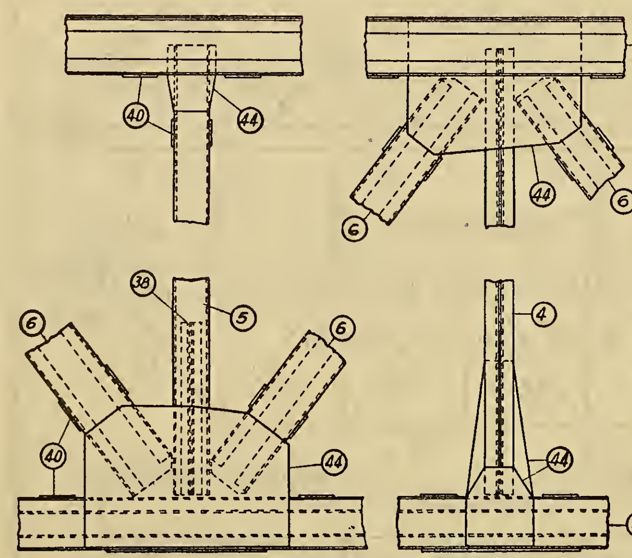


Notes, - Names of Members in Deck Truss Spans similar to those given for Through Truss Spans. Where sufficient information cannot be given by description furnish sketch

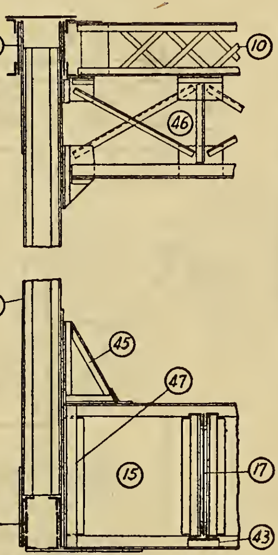
LEGEND		
No.	Description	Location of Individual Members.
1	E.P.	E. or W. End, N. or S. Truss.
2	T. Chord.	State Panel from E. or W. End, N. or S. Truss.
3	B. Chord.	State Panel from E. or W. End, N. or S. Truss.
4	Hanger.	State Panel Point from E. or W. End, N. or S. Truss.
5	I.P.	State Panel Point from E. or W. End, N. or S. Truss.
6	Diag.	State Panel from E. or W. End, N. or S. Truss.
7	Counter.	State Panel from E. or W. End, N. or S. Truss.
8	Ptl.	E. or W. End.
9	Ptl. Bkt.	E. or W. End, N. or S. Truss.
10	T. Strut.	State Panel Point from E. or W. End.
11	T. Lat.	State Panel from E. or W. End.
12	E. Strut.	E. or W. End, N. or S. Side
13	EX. Frm. or Strut.	E. or W. End.
14	E.F. Bm.	E. or W. End.
15	I.F. Bm.	State Panel Point from E. or W. End.
16	E. Str.	E. or W. End, N. or S. Side.
17	I. Str.	State Panel from E. or W. End, N. or S. Side.
18	E. Str. Bkt.	E. or W. End, N. or S. Side.
19	B. Lat.	State Panel from E. or W. End.
20	Str. Lat.	Number E. or W. of Panel Point from E. or W. End.
21	Ex. Shoe.	E. or W. End, N. or S. Truss.
22	Fix. Shoe.	E. or W. End, N. or S. Truss.

Note, - For names of detail parts see, -
"Names of Members in Through Pin Truss Spans."
"Names of Members in Through Rivited Truss Spans."
"Names of Members in Through Plate Girder Spans."

NAMES OF MEMBERS IN THROUGH TRUSS SPANS



TYPICAL DETAILS AT PANEL POINTS.

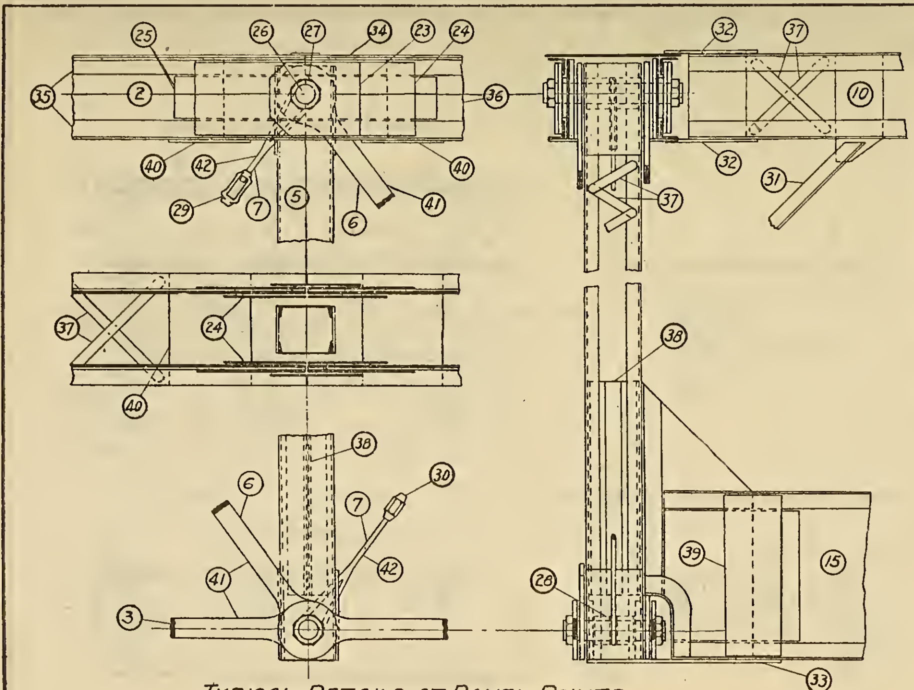


SECTION.

LEGEND		
No.	Description	Location of Individual Members.
2	T. Chord.	For Location see,-"Names of Members in Through Truss Spans.
3	B. Chord.	
4	Hanger.	
5	I.P.	
6	Diag.	
10	T. Strut.	
15	I.F. Bm.	
17	I. Str.	
38	Diaph.	State on which member and where located.
40	Tie Pl.	
43	Shelf L.	
44	Gus. Pl.	State Panel Pt. from E. or W. End, N. or S. Truss, Ins. or Out
45	F. Bm. Bkt.	State F. Bm. to which Bkt. is attached, N. or S. End
46	Sway Frm.	State Panel Point from E. or W. End.
47	Con. L.	State on which member and where located.

NAMES OF MEMBERS IN THROUGH RIVETED TRUSS SPANS

Note,- Where sufficient information cannot be given by description furnish sketch.



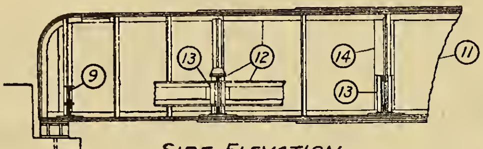
TYPICAL DETAILS AT PANEL POINTS.

LEGEND

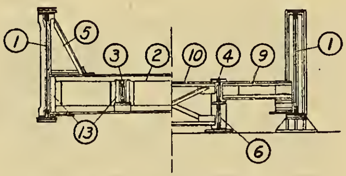
No	Description	Location of Individual Members
2	T.Chord.	For Location see,-"Names of Members in Through Truss Spans."
3	B.Chord	
5	I.P.	
6	Diag.	
7	Counter.	
10	T.Strut.	
15	I.F.Bm.	
23	Jaw Pl.	State on which member and where located.
24	Pin Pl.	
25	Fill. Pl.	
26	Pin.	State Panel Pt. from E. or W. End, N. or S. Truss, T. or B. Chord
27	Pin Nut.	State Pin on which Nut occurs, Ins. or Outs.
28	Pack. Ring.	State Pin on which Pack. Ring occurs.
29	Turnbuckle	State Member on which Turnbuckle occurs.
30	Sleeve Nut.	State Member on which Sleeve Nut occurs.
31	Knee Brace	State Member to which Knee Brace is attached
32	T. Lat. Pl.	State Panel Pt. from E. or W. End, N. or S. Truss, T. or B.
33	B. Lat. Pl.	State Panel Pt. from E. or W. End, N. or S. Truss.
34	Cov. Pl.	State on which member and where located.
35	Flng. L	
36	Web Pl.	
37	Lattice Bar.	
38	Diaph.	
39	Spl. Pl.	
40	Tie Pl.	
41	Eye Bar.	
42	Loop Rd.	

NAMES OF MEMBERS IN THROUGH PIN TRUSS SPANS

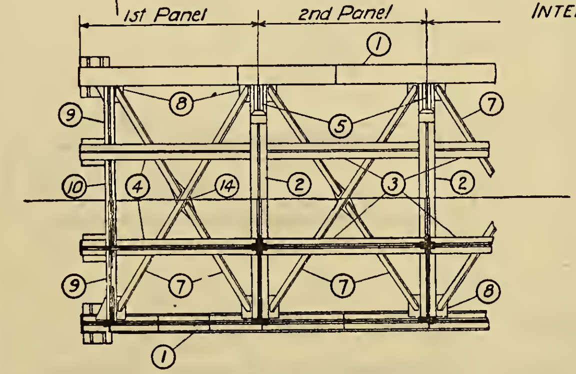
Note.- Where sufficient information cannot be given by description furnish sketch.



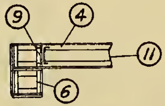
SIDE ELEVATION



INTERMEDIATE AND END SECTIONS



TOP PLAN AND SECTION



END STRINGER PEDESTAL

LEGEND

No.	Description	Location of Individual Members.
1	Main Gir.	N. or S.
2	F. Bm.	Number from E. or W. End.
3	I. Str.	State panel in which Str. occurs, N. or S.
4	E. Str.	E. or W. End, N. or S.
5	F. Bm. Bkt.	State F. Bm. to which Bkt. connects, N. or S.
6	Str. Ped.	State E. Str. which Ped supports
7	Lat. ∠ or Rd.	State Panel from E. or W. End.
8	Lat. Pl.	Number from E. or W. End, N. or S. Gir.
9	E. Strut.	E. or W. End, N. or S. Side
10	E. X. Frm.	E. or W. End.
11	Web Pl.	State on which member and where located.
12	Flng. ∠	
13	Con. ∠	
14	Spl. Pl.	

Note.- For names of parts not numbered compare "Names of Members in Deck Plate Girder Spans"

NAMES OF MEMBERS
IN
THROUGH PLATE GIRDER SPANS

Note.- Where sufficient information cannot be given by description furnish sketch

COMMITTEE XIII.

WATER SERVICE.

[1] DEFINITIONS.

Group "A"—Wells.

Artesian Well.—A well in which subterranean hydrostatic pressure causes the water therein to rise.

Flowing Well.—An artesian well in which the water rises above the surface of the ground.

Driven Well.—One made by driving the casing without screen and removing the material inside, or by driving casing with well point and strainer, without the necessity of removing the material.

Drilled Well.—One, generally of considerable depth, drilled with a tool mechanically operated.

Well Casing.—The pipe forming the wall of a drilled or driven well.

Well Screen.—A device placed in a well, designed to admit water from the surrounding area and exclude sand and other substances therefrom.

Intake Well.—Commonly applied to a well for collecting surface supply in an advantageous position for pumping.

Group "B"—Water Tanks.

Tank Tower.—A structure which supports an elevated tank.

Standpipe.—A cylindrical tank without tower, but performing the same service as an elevated tank.

Tank Valve.—The valve controlling the delivery of water from tank to outlet pipe.

Outlet Pipe.—The pipe through which the water is delivered from tank to spout.

Float Valve.—A valve which controls the height of water in tank by the action of the water raising a float.

Frost Box.—A box insulated for protecting pipes against freezing.

Group "C"—Pipe Lines.

Intake Line.—A line of pipe conveying water by gravity from source of supply to intake well.

Suction Line.—A line of pipe through which a pump draws its supply.

Discharge Line.—A line of pipe through which the water is forced by the action of the pump.

Service Lines.—Pipe lines through which water is distributed.

---

[1] Adopted, Vol. 21, 1920, pp. 66, 1349.

Drop Line.—The vertical line of pipe in a well through which the water is discharged.

Group "D"—Water Columns.

Water Column.—A mechanical device consisting of valve, vertical pipe and spout, through which water is controlled and delivered to locomotive tender.

Group "E"—Internal Combustion Engines.

Internal Combustion Engine.—A prime mover in which the power is derived from the explosive force of the fuel compressed and ignited in a cylinder, and acting directly against the piston.

Two-Cycle Engine.—An internal combustion engine receiving a power impulse at each revolution.

Four-Cycle Engine.—An internal combustion engine receiving a power impulse at each second revolution.

Gasoline Engine.—An internal combustion engine using gasoline, naphtha or other volatile petroleum product as fuel.

Gas Engine.—An internal combustion engine using natural or manufactured gas as fuel.

Oil Engine.—An internal combustion engine which is started and operated on a non-volatile oil of low specific gravity, the fuel being ignited from a surface heated by previous combustion of the fuel.

Group "F"—Water Treatment.

Incrusting Solids.—Matter in solution or suspension which upon the application of heat and evaporation of water forms scale.

Non-Incrusting Solids.—Matter in solution whose solubility is above that usually found in boiler water concentrations.

Colloidal Matter.—Matter in a state of semi-solution which must be coagulated before removal by sedimentation or filtration.

Organic Matter.—Vegetable or animal matter occasionally encountered in waters.

Suspended Matter.—Matter which may be removed by filtration, coagulation or sedimentation.

Filtration.—A mechanical process for removing suspended matter, or bacteria from water.

Aeration.—A process of permeating water with air for the purpose of removing various impurities.

Reagent.—A chemical used for the treatment of water.

Hardness.—The quality of water due to incrusting solids held in solution.

Permanent Hardness.—Formerly referred to that hardness which remained in water after boiling at atmospheric pressure, but from use it now refers to that hardness due to sulphate and chlorides of calcium and magnesium, which results in forming hard scale.

Temporary Hardness.—Formerly referred to that hardness which was removed from water by boiling at atmospheric pressure, but from use refers to that hardness due to calcium and magnesium carbonates, or bicarbonates in solution.

Sludge.—The precipitate resulting from chemical treatment, coagulation or sedimentation.

Intermittent Water Treating Plant.—One so designed that the water is pumped alternately into two or more treating tanks and there retained until chemical reaction and precipitation are complete.

Continuous Water Treating Plant.—One so designed that the untreated water may be pumped to it without interruption and one where the volume of the chambers through which it passes before flowing to storage is sufficient for complete chemical reaction and precipitation.

Group "G"—Equipment.

Reciprocating Pump.—One in which the piston or plunger alternately draws the water in and discharges it from the cylinder.

Single-Acting Pump.—One in which one end of the plunger or piston only acts on the fluid column.

Double-Acting Pump.—One in which the plunger or piston acts upon the fluid column both on the forward and return stroke.

Piston Pump.—One in which a finished cylinder is closely fitted with a reciprocating piston and forces a volume of water varying with the area of piston and the stroke.

Plunger Pump.—One in which the reciprocating part is a plunger which enters the cylinder through packing glands and displaces a volume of water equal to the volume of the plunger entering the cylinder.

Rotary Pump.—One in which the liquid is transferred by catching it between the pump case and revolving impellers which fill the cross-section of the pump case.

Centrifugal Pump.—One in which the force necessary to discharge the water is derived from the velocity of revolving impellers.

Air Lift.—An installation for introducing air into the column of water in a well, thereby causing it to rise.

Working Barrel.—The metal tube fastened to the lower end of the drop line which contains the valves and piston.

Pump Rods.—The line of rods which connect the piston in the working barrel with the power head.

Power Head.—A machine placed over a well connected to the power and which, by means of the pump rods, operates the piston in the working barrel.

Group "H"—Rainfall, Reservoirs, Etc.

Evaporation.—The process by which water is changed from the liquid to the gaseous state.

Precipitation.—Condensed atmospheric moisture.

Runoff.—Precipitation less losses due to evaporation, transpiration and seepage.

Percolation.—The act of water descending from the ground surface.

Transpiration.—The emission of vapor from plant surface.

Interception.—That part of the precipitation prevented from reaching the ground.

Water Table.—The underground water level.

Seepage.—Water escaping through the ground.

[2] GENERAL PRINCIPLES OF WATER SUPPLY SERVICE.

Supply—Quantity.

The supply (if possible within economical limits) should be sufficient so that the total amount of water likely to be required during the average volume of business in twenty-four hours can be drawn from the source in seven hours at terminal stations and in four hours at intermediate stations.

Supply—Source.

Where water of suitable quality and in sufficient quantity can be purchased at a reasonable cost, it is recommended above all other sources.

Springs should be carefully investigated to determine their yield. The possibility or probability of their pollution and the quantity of water likely to be required in the future should be considered. If the daily flow of springs is not largely in excess of the daily quantity required, a reservoir should be constructed.

Lakes, natural ponds, creeks, or rivers require special investigation in each case. The points to be considered are quantity, quality—as regards chemical impurities and amount of sediment carried—future pollution and riparian rights. The style of intake will depend on local conditions entirely; no definite rule can be given.

---

[2] Adopted, Vol. 10, Part 1, 1909, pp. 735-765, 810-814.

In unproved ground, dug well construction should be preceded by test borings to reveal the strata to be penetrated. The character of the strata largely determines the size of the well and the kind of construction necessary.

Artesian deep wells, where obtainable, are a satisfactory source; however, their flow is liable to constant decrease and finally cease.

Deep wells that require pumping usually cost more for maintenance and operation than other sources, are generally for that reason undesirable, but their disadvantages are often compensated by the excellence and security from pollution of the water yielded by them.

Chemical analysis should be made of water from present and prospective sources and the cost of treatment, if required, determined.

PUMPING PLANTS.

The size of the plant should be in accordance with the following table:

Quantity per 24 Hours, in Gallons.	Terminal Stations.		Intermediate Stations.	
	Time Pump to Run in 24 Hours.	Gallons per Minute.	Time Pump to Run in 24 Hours.	Gallons per Minute.
2,000,000	20 Hours......	1666	20 Hours......	1666
1,750,000	20 Hours......	1458	20 Hours......	1458
1,500,000	20 Hours......	1250	20 Hours......	1250
1,250,000	20 Hours......	1042	20 Hours......	1042
1,000,000	20 Hours......	833	20 Hours......	833
900,000	20 Hours......	733	20 Hours......	733
800,000	20 Hours......	666	20 Hours......	666
700,000	20 Hours......	583	20 Hours......	583
600,000	20 Hours......	500	10 Hours......	1000
500,000	7 Hours......	1189	10 Hours......	833
450,000	7 Hours......	1071	10 Hours......	750
400,000	7 Hours......	928	10 Hours......	666
350,000	7 Hours......	838	10 Hours......	583
300,000	7 Hours......	714	10 Hours......	500
250,000	7 Hours......	595	4 Hours......	1041
200,000	7 Hours......	476	4 Hours......	833
150,000	7 Hours......	357	4 Hours......	625
100,000	7 Hours......	238	4 Hours......	416
50,000	7 Hours......	119	4 Hours......	208
25,000	7 Hours......	60	4 Hours......	104

Size of discharge pipe should be decided in accordance with the following:

Use 4-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.355

Use 6-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.437

Use 8-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.519

Use 10-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.656

Use 12-in. Cast-iron Pipe where Qd × H is most nearly equal to 0.820

Use 14-in. Cast-iron Pipe where Qd × H is most nearly equal to 1.162

When Qd = average quantity of water pumped per 24 hours in 1000 gallons and H = friction head in feet for one foot of pipe for quantity of water plant is to handle per minute.

The static head should be obtained. Friction head should be calculated in accordance with friction tables and 50 per cent. added thereto for the ageing of the piping system.

The E.H.P. will be

$$\frac{\text{Gallons per minute} \times (\text{static head} + \text{friction head in feet})}{3960}$$

Steam should be selected for power for plants up to 5 E.H.P. when most of the following conditions obtain:

(a) Where 100 lbs. of coal unloaded into a pump house is cheaper than one gallon of oil delivered at oil storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders in large plants.

(b) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

(c) Where interest charge on a steam plant is less than it would be on an oil plant.

Oil should be selected as a motive power where most of the following conditions obtain:

(a) Where one gallon of oil delivered at oil storage tank is cheaper than 100 lbs. of coal unloaded into the pump house, special consideration being given to locations remote from trackage and isolated stations where train service is such that pumper can, by pumping the whole of his time between trains, do the pumping at two or three stations.

(b) Where the quality of the water is such that it will necessitate heavy boiler repairs, provided boiler compounds cannot be successfully used.

(c) Where interest charge on an oil plant is less than it would be on a steam plant.

The boiler selected should have the relation to E.H.P., as shown by the following table, and should carry 100 lbs. steam.

SIZE OF VERTICAL SUBMERGED FLUE AND LOCOMOTIVE TYPE BOILERS FOR RAILROAD PUMPING PLANTS FROM 1 TO 15 EFFECTIVE HP.

NOTE:—These calculations are based on boiler pressure, 100 lbs.; pump cylinder pressure, 90 lbs.; coal, 11,000 B. T. U., 25 per cent. added for contingencies; pump efficiency, 66⅔ per cent.

E. HP = Gal. per Min. × Head in Ft. ÷ 4000	I. HP at 66⅔% Pump Efficiency	Lbs. Water per Hour at 65° F. to Steam at 100 lbs., to be Evaporated at 36½ lbs. per I. HP.	Sq. Ft. Heat Surface Required for Evaporation at 2.88 Lbs. Water per Hour. per Sq. Ft. Heating Surface	Boiler HP. at 10 Sq. Ft. Heat Surface per HP. per Hour. 25% Added for Contingencies		Lbs. of Coal at 11,000 B. T. U. Burned per Hour to Evaporate Water. Using 2.8 lbs. per E. HP. Hour	Sq. Ft. Grate Area Required for Consumption of 13 lbs. Coal per Sq. Ft. per Hour (Given as Most Economical by Christie Tests.)	Sq. Ft. Grate Area Usually Furnished in Boilers		Lbs. of Coal of 11,000 B. T. U. Burned per Sq. Ft. Grate per Hour to Evaporate Water in Boilers as Usually Furnshd.	
				Actual	Nearest Com'l			Vertical	Loco	Vertical	Loco
1	1.5	55	19	2.8	5	28	2.15	1.76	Not Made	15.8	Not Made
2	3.0	110	38	4.8	5	56	4.32	1.76		31.8	
3	4.5	164	57	7.2	8	84	6.47	3.14		26.7	
4	6.0	219	76	9.5	10	112	8.52	3.14		35.6	
5	7.5	274	95	12.0	12	140	10.80	3.14		44.5	
6	9.0	329	114	14.0	15	168	12.90	4.90	6.3	34.2	26.6
7	10.5	384	134	16.8	20	196	15.00	7.10	9.2	27.6	21.3
8	12.0	438	152	19.0	20	224	17.20	7.10	9.2	31.5	24.3
9	13.5	492	170	21.3	25	252	19.40	7.10	9.2	35.4	27.4
10	15.0	548	188	23.5	25	280	21.60	7.10	9.2	39.5	30.5
11	16.5	603	208	26.1	30	308	23.70	9.60	12.2	32.0	25.2
12	18.0	654	227	28.4	30	336	25.80	9.60	12.2	34.8	27.5
13	19.5	713	247	30.8	35	364	27.00	9.60	12.2	37.9	29.8
14	21.0	768	265	33.2	35	392	30.00	9.60	12.2	40.8	32.1
15	22.5	822	285	35.6	40	420	32.30	9.60	12.2	43.7	34.3

The steam pump selected should have the ratio of water to steam cylinders as large as possible. The water cylinder should be of proper size to discharge the required amount of water per minute, assuming 70 strokes per minute for each cylinder. Pump efficiency should be assumed as 66⅔ per cent. Assuming initial steam pressure at 90 lbs. per square inch obtain steam cylinder pressure per pound water pressure. Proper ratio of water to steam cylinder should be as per Fig. 1. The size of steam cylinder should be in accordance with this size of water cylinder and ratio (see Table 1).

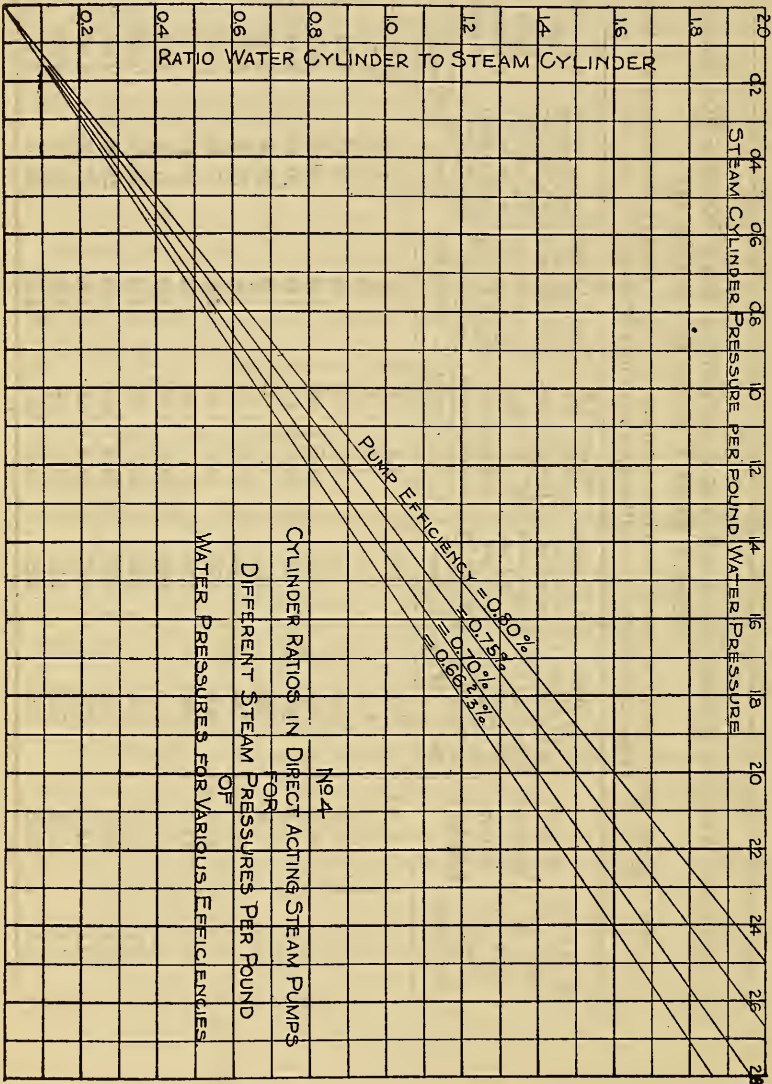


Fig. 1.

TABLE 1

Table Showing Ratio of Area of Water Cylinders to Steam Cylinders for Various Standard Sizes Direct Acting Steam Pumps

$$\text{Ratio} = \frac{\text{Area of Water Cylinder}}{\text{Area of Steam Cylinder}}$$

Diameter Cylinders		Ratio	Diameter Cylinders		Ratio	Diameter Cylinders		Ratio
Steam	Water		Steam	Water		Steam	Water	
6	5	0.69	6	7½	1.56	7	10	2.04
7	5	0.51	7½	7½	1.00	8	10	1.56
7½	5	0.44	8	7½	0.88	10	10	1.00
8	5	0.39	12	7½	0.39	12	10	0.69
9	5	0.31	14	7½	0.29	14	10	0.51
10	5	0.25	16	7½	0.22	16	10	0.39
						17	10	0.35
5	5½	1.21	6	8	1.78	18	10	0.31
5½	5½	1.00	8	8	1.00	20	10	0.25
6	5½	0.84	10	8	0.64	22	10	0.21
10	5½	0.30	12	8	0.44			
12	5½	0.21	14	8	0.33	7½	10¼	1.87
			16	8	0.25	9	10¼	1.30
5¼	5¾	1.20				10	10¼	1.05
6	5¾	0.92	6	8½	2.01	12	10¼	0.73
7½	5¾	0.59	7	8½	1.48	14	10¼	0.54
			7½	8½	1.28	16	10¼	0.41
6	6	1.00	8	8½	1.13	17	10¼	0.36
7	6	0.73	9	8½	0.89	18½	10¼	0.31
7½	6	0.64	10	8½	0.72	20	10¼	0.26
8	6	0.56	12	8½	0.50			
9	6	0.44	14	8½	0.37	17	11	0.42
10	6	0.36	16	8½	0.28	20	11	0.30
12	6	0.25	17	8½	0.25			
			18	8½	0.22	8	12	2.25
5¼	6¾	1.65	18½	8½	0.21	9	12	1.78
7	6¾	0.93				10	12	1.44
			14	9	0.41	12	12	1.00
6	7	1.36	16	9	0.32	14	12	0.73
7	7	1.00	18	9	0.25	16	12	0.56
7½	7	0.87	20	9	0.20	17	12	0.50
8	7	0.77				18	12	0.44
10	7	0.49	12	9¼	0.59	18½	12	0.42
12	7	0.34	14	9¼	0.44	20	12	0.36
14	7	0.25	16	9¼	0.33	22	12	0.30
			18½	9¼	0.25	24	12	0.25
			20	9¼	0.21	26	12	0.21

The oil engine selected should have a commercial brake horsepower rating of twice the effective horsepower.

The power pump, where suction lift is such that the pump can be on same level as engine, may be of the triple single-acting type, or duplex double-acting, direct-connected to engine friction clutch. For small plants the combined engine and pump are recommended.

The power pump in small plants where suction lift is such that the pump must be at a lower level than engine, should be single cylinder, double-acting type, connected to engine by means of a pitman face plate and shaft. In larger plants a two or three cylinder pump with pump head and extension rods, with guides where necessary, will be found more advantageous.

Pump houses should be constructed of non-combustible material wherever practicable. In gasoline plants the engine should be in a separate room, with floor vents. Stoves and lights should not be permitted in gasoline engine rooms. The gasoline supply should be kept outside the house. Where there are deep wells, the house should be so designed that it can be removed or opened to admit of a well machine being placed over it. At terminal stations the pump house should be incorporated with other part of plant where possible.

Each plant should be fitted with a pressure gage on discharge pipe and a revolution counter on pump.

[8] IMPOUNDING RESERVOIRS FOR RAILWAY PURPOSES.

Introduction.

The most desirable site is one from which water can be delivered by gravity or involves the least pumping head.

The impounding area should be sufficient to maintain an adequate supply throughout the longest dry period, which may extend over two consecutive years. (See Plate "A.")

Conditions of Economy (Operating).

Impounding reservoirs are justified at places where the cost of water delivered does not exceed that of other equally usuable dependable supply.

Selection of Site.

Reservoirs should be located where the topographic and climatic conditions are most favorable. The governing factors are as follows:

---

[8] Adopted, Vol. 21, 1920, pp. 59, 1348.

Topographic:

- Geographical Elevation.
- Geographical Formation.
- Topography.
- Drainage Area.
- Accessibility.
- Exposure.
- Size of Reservoir.
- Shape.
- Depth.
- Water Table.
- Seepage from Reservoir.

Climatic:

- Temperature.
- Wind.
- Humidity.
- Storm Path.
- Precipitation.
- Land Evaporation.
- Transpiration.
- Interception.
- Runoff.
  - Surface.
  - Sub-Surface.
- Water Evaporation.

Drainage Area.

This may be comparatively small, requiring from a fraction of a square mile in regions of frequent precipitation to a number of square miles in the more arid localities; the area increasing with a decrease in rainfall. The area should be favorable to a considerable surface runoff. An excessive area increases amount of silt and size of spillway.

The ratio of drainage area to spillway contour should be not less than 35 or 40, and the reservoir should have a water depth approximating 25 feet.

Water Requirements.

The maximum demands for present or the near future use should be determined. The growth of traffic should be studied for a guide in forecasting the probable ultimate needs.

Land Evaporation.

This is principally influenced by temperature and wind and usually varies from about one-fourth to two-thirds of the yearly rainfall.

Transpiration.

This is mainly influenced by temperature and moisture and generally varies from four to ten inches during the growing season for areas having mixed vegetation, the water requirements for plants varying from three hundred to one thousand times the weight of the dry matter produced.

Interception.

This is the portion of the precipitation intercepted and evaporated without reaching the ground, and is in a measure constant for each rain and probably amounts to 0.10 inch per rain, or something like 15 per cent. to 40 per cent. of the annual precipitation. This item is often included in the land evaporation loss.

Runoff—Surface and Sub-Surface.

This is the residual precipitation after land evaporation, transpiration, interception and deep seepage losses have been deducted, and varies generally from 5 per cent. to 50 per cent. of the annual precipitation: often a rainfall of one-half inch is required before there is an appreciable surface runoff.

In this class of reservoirs the surface runoff is the main factor sought and is in general one-half and often greater than one-half the total runoff.

Method of Determining Runoff.

All rainfall records near site and in storm path should be carefully studied and platted, likewise the daily rainfall, temperature, wind and humidity records for the period for which the calculations are made. (See Plate "A.")

Runoff computations should be made for the year preceding a drought for the duration of the dry period; while the computations for the spillway should be based on the heaviest precipitations.

The various methods can be grouped into four classes, viz.:

1. The formula group.
2. The percentage group.
3. The precipitation minus loss method.
4. The direct measurement method.

Water Evaporation.

This depends chiefly on temperature, but is largely influenced by the wind and humidity. In the more arid regions evaporation from reservoir surface is the greatest loss.

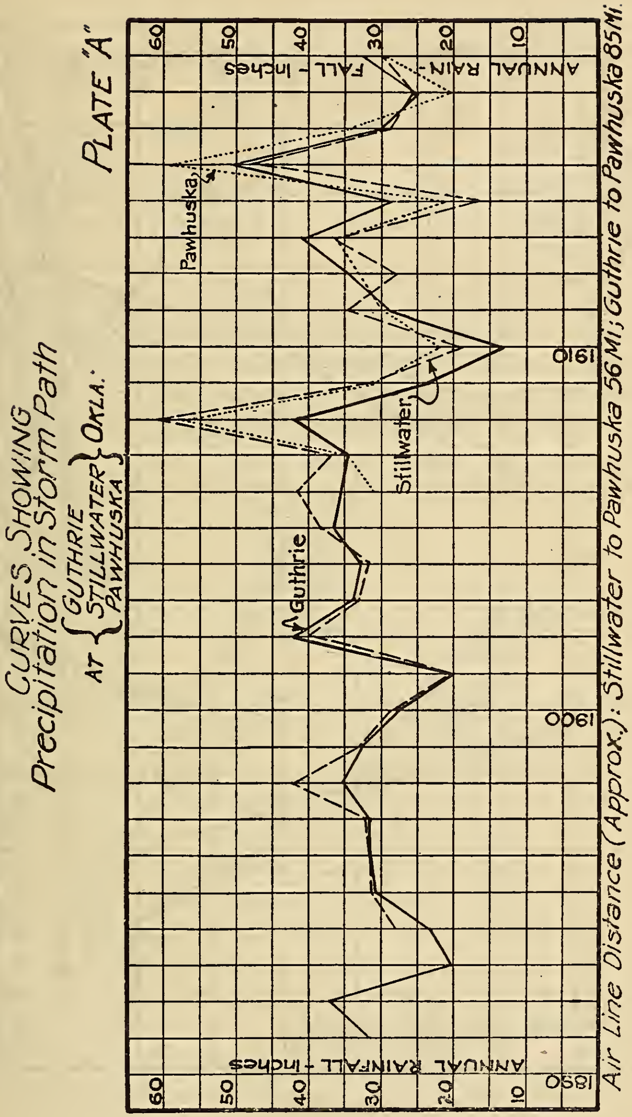


Plate "A" Indicates the Close Relationship in Precipitation at Scattered Points in the Storm Path.

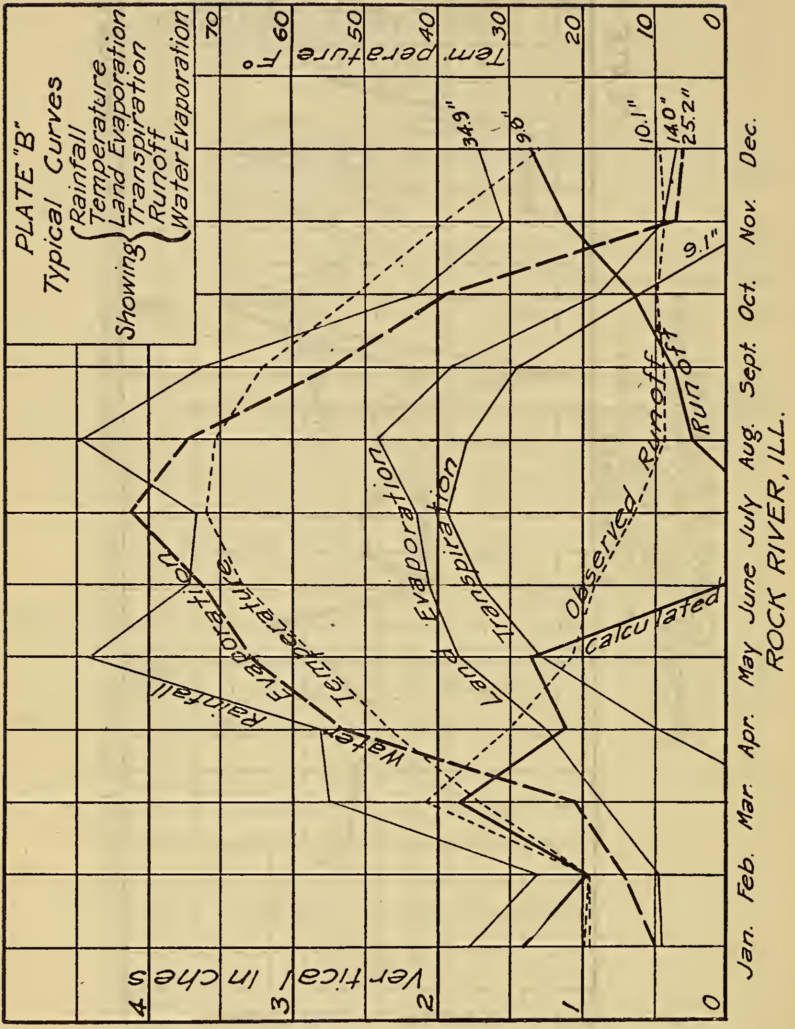


Plate "B" Shows Typical Curves for Monthly Values for the Various Factors Entering Into This Subject and Apply to Northern Illinois.

[4] WATER METERS FOR USE IN RAILWAY WATER SERVICE, METHODS FOR TESTING AND READING METERS, AND CHECKING CONSUMPTION OF WATER.

Reading Meters.

1. The straight reading indicator consists of revolving discs with figures around their periphery revolving on a common shaft, the figures denoting the meter reading are exposed through a slot in the dial face. This type of indicator requires no instructions, as it is only necessary to copy the figures as shown.

The standard indicator consists of a train of clock gears and pinions, with points indicating on numbered circles or indices the figures which form the meter reading. The standard indicator is in almost general use, as it is much simpler in mechanism and is less liable to get out of order than the straight reading indicator. Accuracy is of the greatest importance in meter reading and familiarity with the work and appearance of the dials under various conditions of moisture, dirt, etc., is necessary to enable the meter reader to do his work accurately.

General Instructions.

2. (a) Before attempting to read a water meter be sure that it is registering. If necessary turn on the water and note if the point of indice moves.

(b) Begin reading the meter by noting the value of the unit in which the dial reads; this is indicated by each indice. These figures indicate the value of one completed revolution of the points, therefore each division of an indice represents one-tenth of the amount marked against each indice. It should be noted that one complete revolution of a point of any indice is equal to one division of the indice of next higher value.

(c) Care must be taken to note the direction of movement of the points which rotate on alternate dials in opposite directions.

(d) Read the indices beginning with the one of lowest value, usually marked 10, and continue in the order shown by the figures beneath each indice, setting down the figures as read, i. e., the reading of the 10 indice in the units column; that of the 100 indice in the tens column, etc.

(e) Always set down the figure on each indice that has been passed last or is just covered by the pointer, as the reading of each indice depends upon the reading of the one of next lowest value. Care must be taken, when the point of the indice being read is close to, or covering a figure, for unless the indice of next lower value has completed a revolution, or passed the 0, the pointer which is being read has not completed the division upon which it may appear to rest and the last figure which it has entirely passed should be set down on the record.

---

[4] Adopted, Vol. 21, 1920, pp. 63, 1348.

(f) When the meter has registered its full capacity, that is, one complete revolution of the highest dial, it returns to 0 and starts again. Whenever this occurs place in front of the reading of all of the dials the figure 1—this must be done to obtain the present reading.

(g) Dials are made to indicate cubic feet, gallons, liters or any other unit.

Accuracy of Meters.

Positive displacement water meter when new should test within the following degrees of accuracy:

⅝-inch meters within 2 per cent. plus, or minus, on all flows from 20 gallons per minute down to one gallon per minute, and within 10 per cent. minus on ¾ gallons per minute.

¾-inch meters within 2 per cent. plus, or minus, on all flows from 35 gallons per minute down to 2 gallons per minute and within 10 per cent. minus on ½-gallon per minute.

1-inch meters within 2 per cent. plus, or minus, on all flows from 60 gallons per minute down to 3 gallons per minute, and within 10 per cent. minus on ¾ gallons per minute.

1½-inch meters within 2 per cent. plus, or minus, on all flows from 100 gallons per minute down to 5 gallons per minute, and within 10 per cent. minus on 1½ gallons per minute.

2-inch meters within 2 per cent. plus, or minus, on all flows from 160 gallons per minute down to 8 gallons per minute, and within 10 per cent. minus on 2 gallons per minute.

3-inch meters within 2 per cent. plus, or minus, on all flows from 320 gallons per minute down to 16 gallons per minute, and within 10 per cent. minus on 4 gallons per minute.

4-inch meters within 2 per cent. plus, or minus, on all flows from 560 gallons per minute down to 28 gallons per minute, and within 10 per cent. minus on 7 gallons per minute.

6-inch meters within 2 per cent. plus, or minus, on all flows from 960 gallons per minute down to 48 gallons per minute, and within 10 per cent. minus on 12 gallons per minute.

Testing Meters.

The correct method of testing water meters is by weighing the water, allowing 62.5 lb. of water to the cubic foot, and this method should be followed whenever possible. (Variations in volume due to temperature being generally disregarded in actual practice.)

To ascertain the percentage of registration divide 6,250 by the number of pounds of water delivered by meter.

To determine the percentage of error in registration, multiply the error in pounds per cubic foot by 16 and divide by 10. It is necessary to run at least one complete revolution of the hand of first indice of the meter dial in all tests, as the graduations of the indice may not be exact.

When necessary to make several runs to complete one revolution of the first indice, the total weight of water delivered in the several runs should be added, and in no case should a sub-division of the circle be used to calculate the accuracy of the meter. When testing a meter, a valve should be placed on the outlet side of the meter and a pressure maintained, making the conditions of test similar to that of actual service.

When the test by weight is impractical meters may be tested in place by using a hose or pipe from the outlet of meter to a test meter of known accuracy.

Maintenance of Meters.

The maintenance of water meters is largely a matter of inspection, testing and cleaning. The total cost of repair parts usually represents but a very small proportion of the expense of maintaining meters.

Where water is furnished through a meter, the meter is generally maintained by the parties furnishing the water, regardless of ownership of meter. In justice to both parties the meter should be maintained as closely as possible to the same degree of accuracy as when received from the manufacturer.

Whenever practical a railroad should standardize its water meters, as this enables employees to so familiarize and perfect themselves in the knowledge of the mechanical construction as to maintain a system of meters at least expense and greatest efficiency.

Hot Water Meters.

A hot water meter is similar in construction to a cold water meter except that bronze or similar metal is used for discs, etc., instead of vulcanized rubber, as the hard rubber used in cold water meters becomes pliable at about 120 deg. Fahr. A hot water meter should not be used in continuous service for either hot or cold water, as the metal working parts wear much more rapidly than in the cold water meter where dissimilar substances come in contact.

The principal use of hot water meters is to measure boiler feed water.

Types of Meters Suitable for Railway Service.

While all types of meters are used successfully in railway water service, their use may be well confined to two types for general service, namely, the disc and current type of meter.

The disc type of meter is very satisfactory in the smaller sizes and for fairly uniform flow up to three inches. The area of the disc is so great in the larger sizes that they are easily damaged through water hammer; therefore, a current meter should be used for services larger than three inches.

The current or velocity type of meter is designed for the rapid delivery of a large quantity of water, and is a very durable type of meter under heavy duty. The water areas are large as compared to the wearing surfaces and the wear is not as great as with other types of meters even when handling muddy or gritty water.

[5] WATER SERVICE ORGANIZATION.

(1) The object of this department is the economical development, construction, maintenance, and operation of water stations for supplying suitable water for locomotives and other railway purposes and to secure efficiency with a minimum of changes in the existing organization.

(2) The establishment of a water department organization does not necessarily mean that the division, or local forces, are materially changed, but rather that the duties pertaining to the development and operation of water facilities are placed in the hands of those trained along this particular line, relieving local and other officers of duties which may be foreign to their department. Where regular water service men are locally employed and the nucleus of an organization exists, as on many roads, the divisional organization remains practically unchanged except that duties and responsibilities are more clearly defined.

(3) The graphical chart submitted represents an organization suitable for a railroad of large mileage, and may be readily adapted to any road with modifications.

(4) Superintendent or Engineer of Water Service shall have direct charge of chemist, inspectors and construction forces, and acts in an advisory capacity to the division forces. A monthly report of the operation of water stations shall be forwarded to the Superintendent or Engineer of Water Service, together with all other reports relating to water facilities.

---

[5] Adopted, Vol. 21, 1920, pp. 57, 1348.

City water bills, requisitions for materials used in the construction and maintenance of water facilities, as well as agreements pertaining to water supply, shall be approved by him.

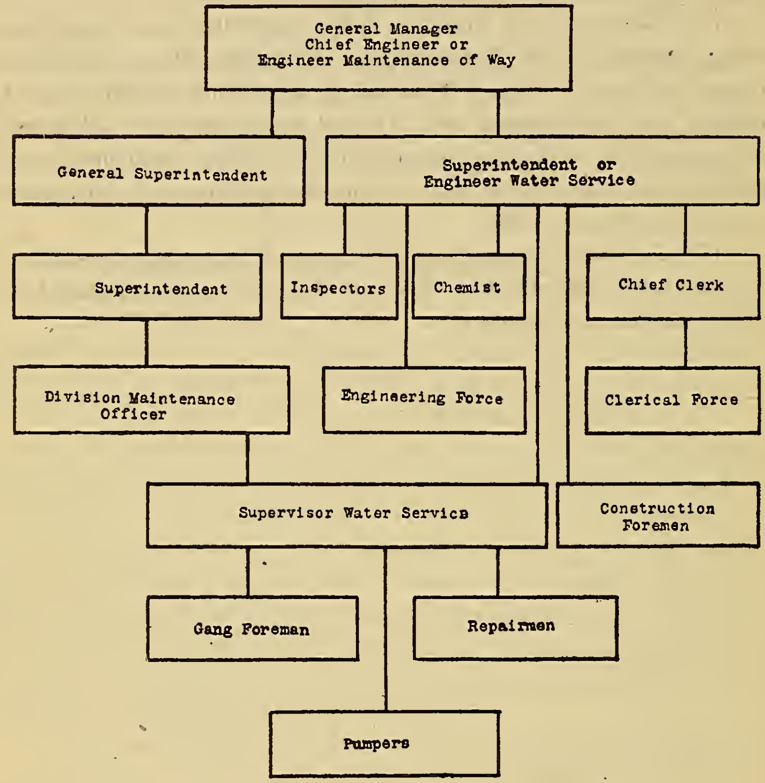
(5) *Chemist*—The chemist shall report to the Superintendent or Engineer Water Service, and shall have supervision of water treatment and the analysis and examination of water. He shall periodically check the results of treatment, including the effect of treated water on the maintenance and performance of locomotive and other boilers.

(6) *Inspectors*—The inspector shall periodically inspect water stations, reporting to the Superintendent or Engineer Water Service on proper form the conditions in detail and the repairs and renewals required, together with the estimated cost. He will make inspections and reports on construction work, see that standards are being maintained, check estimates and recommended improvements and perform such other duties as may be assigned to him.

(7) *Supervisor Water Service*—Supervisor Water Service shall report to Division Maintenance Office, and shall have charge of gang foremen, repairmen and pumpers.

He shall be responsible for the condition, maintenance and operation of pumping machinery, tanks, fire hydrants, fire pumps, pipe lines and all other facilities for handling water on his territory.

WATER SERVICE ORGANIZATION.



(8) *Construction Foreman*—Construction foreman shall report to the Superintendent or Engineer Water Service and shall have charge of construction forces and perform such other work as may be assigned to him.

[6] INSTRUCTIONS FOR CARE OF WATER STATIONS.

Duties of Attendant.

The Pumper, Station Agent or other person in charge of the local water supply will be held responsible for the condition of the entire plant. His first duty will be to see that there is an ample supply of water available for locomotive use at all times.

In case of trouble that affects the water supply he must wire the Chief Dispatcher as well as the Supervisor Water Service, stating fully the trouble and what is needed for repairs. He must make frequent inspection of all parts of the plant, make all repairs within his power and avoid sending for repairman except when absolutely necessary. He will be responsible for the safekeeping and economical use of supplies furnished to the water station and place orders for fuel and supplies in ample time to avoid a shutdown of the plant.

Pumphouse.

The attendant must keep pumphouse neat and clean and take every precaution against loss or damage by fire. Waste or other combustible material must not be stored in the pumphouse. Oil and gasoline must be stored outside in proper receptacles. Cinders must not be dumped close enough to the house to endanger it. Proper place must be provided for all tools and they must be returned to their proper place after using.

Machinery.

Machinery must be inspected daily and adjustments made to increase efficiency and to prevent wear or breakdown. Particular attention must be given to the packing and lubrication of all parts. Attendant must be familiar with the location and purpose of all steam and water pipes, valves, levers, etc., so that in case of accident or leaks the controlling valves may be properly used.

When ordering repair parts for any piece of machinery attendant must always give the name of manufacturer, shop number of the machine and repair number of the part wanted.

Boilers.

Attendant must see that the boiler contains a sufficient amount of water before starting a fire and that the gage-cocks, water glass and safety valve are clean and in good condition.

Fire must be frequently cleaned of clinkers, and ashes and soot removed from flues. Ashes must not be allowed to accumulate beneath the grate.

---

[6] Adopted, Vol. 20, 1919, pp. 318, 911.

Boiler must be washed out once a week or oftener if in the judgment of the Supervisor Water Service it is necessary. Foaming is due to a dirty boiler and can be stopped by blowing down and filling with fresh water. To blow down the boiler, first fill it to the top with water, then blow down to one gage with not over 30 lb. of steam.

If it develops, when plant is operating, that no water appears in the water glass the valve below water column should be opened. If water then appears, the flow to the boiler can be increased; if not, fire must be pulled and boiler cooled before turning any water into it. Where more than one shift is in charge of the pumping plant each oncoming man should be notified by the man leaving, of any defects.

Should safety valve stick and steam gage show over-pressure, draft doors should be closed and boiler allowed to cool off to pressure at which valve is supposed to work before any repairs or adjustments of the safety valve are attempted.

Oil Engines.

Attendant must be provided with a copy of and be governed by the manufacturer's printed instructions for operating the particular type of engine in his charge.

To secure economical and satisfactory operation, engines must be properly lubricated. Attendant must see that all moving parts are free from dirt, properly oiled and work easily. Lubricating oil must be fluid enough to be fed readily through the oiler. When oiler is being filled the lubricating oil should be run through a fine mesh strainer inserted in a funnel. The cover of the oiler should be in place at all times except when filling it. The oiler should be drained occasionally and washed out with gasoline. This applies also to the bearing oil cups.

The machinery to be driven should be detached from the engine until engine is in motion.

Before starting see that tank contains fuel and that a supply of cooling water is available. Thermometers are frequently provided which show the temperature of the cooling water around the cylinder. When running the thermometer should register 140 to 180 degrees Fahrenheit. The most favorable temperature will be different with different fuels and attendant should note the temperature at which operation is best and attempt to keep it reasonably close to that figure. The temperature can be held at that point by regulating the supply of water to the cylinder jacket by means of the valve provided for that purpose. The pump, piping and water jacket of the engine must be drained when engine is not in use to prevent freezing and cracking of cylinder.

Fuel for oil engine should be strained at the time storage tank is filled. In some types of engines fuel is injected into cylinder through a spray nozzle. Irregular operation may be caused by foreign matter in the oil sticking in the spray nozzle or in the check valve in the injector pump. The small hole in end of spray nozzle must be cleaned occasionally.

If a loss of compression is noticed, piston should be inspected. The piston rings should be free in their grooves. If they stick, the compression or explosion will blow past them and the combustion will be poor, due to poor compression. Any accumulation of carbon which tends to stick to the rings should be washed out with gasoline.

Electric Motors.

Motor, control and pump should be inspected at least once each week, at which time all parts should be thoroughly cleaned, and all contact carefully inspected to see that they make and break at proper time and that contact surfaces are clean. All wearing parts should be well lubricated and special attention should be given to motor bearings. Building where motor is located should be kept clean. No papers or oily waste should be allowed to collect in switch boxes or near motor or near any electrical contact or wires.

Waste must not be used around commutator or brushes and gasoline or sandpaper must not be used to clean commutator. If motor sparks excessively the proper official should be notified.

Motor should be watched carefully for overheating. The commutator should not be allowed to become worn or grooved by the brushes.

Any displaced wire must be reported. No attachments should be made to the wiring, as serious damage may be done to the equipment and there is danger of personal injury. A fuse must never be replaced with anything but a proper fuse. If one of a higher ampere rating is used it may cause serious damage to the motor. The fuse is the electrical safety valve and should no more be tampered with than a steam safety valve. A test lamp should be used to find blown fuses, thus avoiding chances of electric shocks. A gage should be applied to each alternating current motor to test the space between motor and field poles. If gage will not pass freely the bearings need immediate attention.

On pump motors controlled from a distance, the remote control starter located in the pumphouse should be inspected and tested frequently to see that it starts the motor properly. Any badly burned contact should be reported.

Water Tanks.

They should be filled at each pumping to prevent shrinkage of wooden tanks, deterioration in sheets of metal tanks, as well as to safeguard the water supply in case of accident to the pumping plant. Tank spouts and grab ropes must be maintained at standard clearance. Defects in spouts, valves or discharge pipes must be reported at once. Attendant must watch engines take water and report unnecessary waste. Damage to fixtures or appliances by engines taking water must be reported to the Supervisor Water Service, giving date, train and engine number.

Water Columns.

Water columns should be inspected frequently and maintained in good working order. Lifting rods should be tightened, leaky glands repacked, locks and rollers adjusted. On double track, water columns should be swung in the direction of traffic and locks maintained in such position that they hold the water column parallel to the track.

EXAMINATION QUESTIONS FOR CARE OF BOILERS.

1. (Q.) Describe in a general way the principal parts of a steam boiler and their uses.

(A.) A *steam boiler* is a vessel used to generate steam. A *firebox* or *furnace* is provided for the combustion of fuel such as coal or wood. The *smokestack* is connected with the furnace to carry away the gases of combustion and create a draft, that is, supply the burning fuel with air. An *injector* or *feed pump* supplies the water to the boiler for the generation of steam. The *steam gage* indicates the steam pressure, while the *water glass* and *gage cocks* show the height of water in the boiler. The *safety valve* is a device attached to the boiler for the purpose of assuring its safety against explosion from excessive pressure of the steam. It automatically opens when the pressure exceeds a certain limit and closes again when the pressure has fallen slightly.

2. (Q.) What is essential for the safety of a steam boiler?

(A.) A safe head of water in the boiler and a safety valve properly set and in good order.

3. (Q.) What is necessary for the proper burning of coal?

(A.) Clean flues and smoke connections and careful, even firing, keeping the fire open and free from clinkers and supplying it with the proper amount of air.

4. (Q.) What is the result of putting too much coal on a fire?

(A.) Incomplete combustion and black smoke and poor steaming effect.

5. (Q.) What is the result of carrying too thin a fire?

(A.) An uneven fire with too much air supply and poor steaming effect.

6. (Q.) (a) Of what does black smoke consist?

(b) How can it be prevented?

(A.) (a) Carbon and unburnt gases.

(b) By careful, even firing.

7. (Q.) What is the result of letting ashes accumulate beneath the grate?

(A.) A poor draft and generally the warping and burning of grates.

8. (Q.) What is the result of letting clinkers gather on the grate?

(A.) A poor fire and burning out of grates.

9. (Q.) For what purpose is the water glass used?

(A.) To indicate the height of water in boiler.

10. (Q.) What is the use of the blow-off cock?

(A.) To blow off the sediment in the bottom of the boiler. This assists in correcting foaming and priming.

11. (Q.) How would you blow down a boiler while running with a good fire?

(A.) Never leave the blow-off valve and watch the water level in water glass.

12. (Q.) How much water should be blown down at one time while running?

(A.) Never blow off more than one gage of water while running.

13. (Q.) How would you prepare a fire to last through the night without further attention?

(A.) Clean the fire carefully, removing all clinkers, and bank the fire well with wet slack coal.

14. (Q.) What is priming and foaming?

(A.) Priming is the formation of wet steam which rises with such rapidity as to violently agitate the water. Small globules of water are thrown off from the surface, mixed with the steam and are carried off with it. Foaming is an aggravated form of priming, where the water is thrown up in large quantities and carried off into the pump.

15. (Q.) How would you know when the water is foaming?

(A.) By the restless action of the water in the gage-glass.

16. (Q.) How would you stop a violent case of foaming?

(A.) Frequent blowing off of boiler and supplying it with fresh water will generally correct the trouble.

17. (Q.) If you suddenly discovered there was no water in the glass what would you do?

(A.) If a light fire draw and cool off as quickly as possible; if a heavy fire cover with wet ashes or slack coal. Never open or close any outlets of steam when water is out of sight.

18. (Q.) In starting a steam pump what would you do first?

(A.) Open all cylinder cocks on steam cylinder in order to let out condensed steam and fill the lubricator.

19. (Q.) Describe the next step.

(A.) Open the throttle valve a trifle in order to warm up the cylinder and give the condensed steam time to run out of cylinder.

20. (Q.) In case of accident to the pumping plant which affects the water supply what would be your first duty?

(A.) Wire the Chief Dispatcher and Water Service Foreman, stating fully the trouble and what is needed for repairs and then if possible make such temporary repairs as are necessary to keep the station in service until permanent repairs are made.

21. (Q.) How should pumphouses be kept?

(A.) Neat and clean and every precaution taken to prevent fire.

22. (Q.) Where should oil and waste be stored?

(A.) In metal boxes or receptacles outside the pumphouse.

23. (Q.) What will be your duty regarding care of water columns?

(A.) See that they are properly lubricated and in good working order and that the spring locks and rollers are adjusted so that column will stand parallel to the track when not in use. See that leaky valves and glands are repacked.

24. (Q.) Describe some of your other duties.

(A.) Watch engines take water, report unnecessary waste or damage to tank or fixtures or water columns, giving date, train and engine number.

Examination Questions for Care of Internal Combustion Engines

1. (Q.) What is an internal combustion engine?

(A.) An engine run by an explosive force applied directly to the piston, an explosive mixture composed chiefly of air, in which has been blended the fuel used, oil, gas or gasoline, introduced into the cylinder, compressed and then ignited. The expansion of the explosion which occurs in the cylinder is one of the greatest forces known and forces the piston out and the power thus generated is transmitted to the crank shaft.

2. (Q.) What is a two-cycle engine?

(A.) A two-cycle engine is one in which an explosion occurs during every revolution of the crank.

3. (Q.) What is a four-cycle engine?

(A.) A four-cycle engine is one in which an explosion occurs during every other revolution of the crank.

4. (Q.) What is a carburetor and its functions?

(A.) A carburetor is a device for forming an explosive mixture of air and gasoline or other oil. It is provided with a needle valve for gas or oil and a throttle valve for air in order that a proper mixture may be made of the air and oil.

5. (Q.) What is a needle valve?

(A.) A needle valve is used on oil feed lines; the valve proper is provided with a very fine point to keep the orifice free of obstructions and permit of a close regulation of the oil.

6. (Q.) What form of ignition is commonly used on gasoline and oil engines?

(A.) Ignitors and spark plugs on gasoline and kerosene engines and hot bulb or tube on oil engines.

7. (Q.) What is the difference between an ignitor and a spark plug?

(A.) The spark is formed on an ignitor by breaking the contact between contact points of ignitor and is commonly known as make-and-break ignition. The spark is formed on a spark plug by a vibrator which causes the spark to pass between two fixed contact points and is known as jump-spark ignition.

8. (Q.) Explain the hot bulb or tube method of ignition.

(A.) The bulb or tube is heated by a torch before starting and kept hot by the successive explosions in the engine cylinder, the temperature being regulated by the cooling water, through cylinder head.

9. (Q.) What is an explosive mixture?

(A.) An explosive mixture consists of vaporized oil and air in the proper proportions.

10. (Q.) (a) What would be the temperature of the cylinder of an engine operating on gasoline?

(b) On oil?

(A.) (a) The temperature required for a gasoline engine cylinder varies from 100 degrees to 160 degrees, depending on mixture, condition of cylinder, etc.; the temperature should not be high enough to cause pre-ignition or loss of power.

(b) To insure good combustion the temperature of an oil engine cylinder should be from 150 to 160 degrees.

11. (Q.) What are the causes of hot bearings?

(A.) Friction because of tight bearings, lack of lubrication and loose bearings, causing bearing to pound hot.

12. (Q.) What should be done to correct a hot bearing?

(A.) The bearing should be carefully adjusted to eliminate unnecsary friction and pounding and the bearing properly lubricated. Water may be used on the bearing to keep the heat below the danger point until it has become properly seated. Excessive heat will cause the bearing to expand and stick.

13. (Q.) What is the effect of too much oil in the cylinder?

(A.) If too much oil is used a slow burning mixture is formed which does not develop the power that a proper explosive mixture does, causes incomplete combustion and formation of carbon.

14. (Q.) What are some of the causes of carbonization?

(A.) Carbonization is chiefly due to insufficient heat in the combustion chamber and may be caused by an overloaded engine using more oil than the heat from the combustion chamber can vaporize. It is important to prevent carbonization that the piston rings are a perfect fit to the cylinder walls, otherwise the gases may blow by the rings, causing them to become fast in the grooves of the piston.

15. (Q.) How should piston rings be loosened when stuck in the grooves of the piston?

(A.) The rings should be soaked with kerosene, loosened up and grooves carefully cleaned.

16. (Q.) How would you remove the rings?

(A.) The rings can be removed by taking three strips of tin one-half inch wide and five or six inches long, slip one strip under each end of the spring and the third strip under the middle of the ring. The ring may then be slipped out of the groove and cleaned.

17. (Q.) How would you regrind inlet and exhaust valves?

(A.) To reseat valves grind with emery and oil by revolving valve on seat until it will hold compression, carefully clean both valves and seat before starting engine.

18. (Q.) What causes knocking in an engine?

(A.) Knocking may be caused by loose crank brasses, piston brasses or bearings. Loose piston rings cause a knock in the cylinder which is sometimes very hard to locate. Pre-ignition will also cause knocking in the cylinder.

19. (Q.) What causes pre-ignition?

(A.) Pre-ignition may be caused by an overload on the engine, by ignition of carbon deposit on cylinder walls and head and by the cylinder being too hot.

20. (Q.) What are the principal causes contributing to the rapid deterioration of internal combustion engines?

(A.) Lack of proper lubrication and absence of cooling water on jacket are two principal causes of the deterioration of an internal combustion engine.

Examination Questions for Care of Electrically Operated Pumps

1. (Q.) What are the two kinds of current generated?

(A.) Direct and alternating current.

2. (Q.) How would you distinguish between the two motors?

(A.) The direct current motor will have a commutator and brushes, the alternating current motor will have neither commutator nor brushes.

3. (Q.) How should a direct current motor be started?

(A.) The arm of the starter should be moved slowly over the contacts from the "off" to the "on" position as the motor comes up to speed.

4. (Q.) How should an alternating current motor be started?

(A.) This type of motor is usually started with an auto-starter, the lever of which should be thrown first to starting position and held until motor has attained normal speed and then to the running position.

5. (Q.) What would be the result of bringing the starter handle over quickly?

(A.) The rush of current might blow a fuse, trip a circuit breaker or possibly injure the insulation of the motor windings.

6. (Q.) What is the proper method of stopping both the direct and alternating current motors?
(A.) By opening the motor switch.

7. (Q.) When using a direct current motor how should the commutators be cleaned?
(A.) With a rag moistened with signal oil.

8. (Q.) What are the indications of overheating in a motor?
(A.) A fried or charred appearance of the insulation of the windings, especially the armature.

9. (Q.) What would indicate the proper temperature of motor?
(A.) After running an hour or two the field coils and armature should be warm, but not enough to be uncomfortable to the hand.

10. (Q.) How often should motors be lubricated?
(A.) Once a month.

11. (Q.) How would you proceed to lubricate a motor?
(A.) The oil should be drained from the boxes, the boxes cleaned and refilled with clean oil.

[7] QUALITY OF WATER—METHOD OF TREATMENT.

General.

(1) Location of water stations and quality of water being factors affecting operating efficiency, investigation of available supplies should be made, securing as nearly as practicable favorable locations and elimination of water of inferior quality.

(2) Water usually contains scale forming matters in solution or suspension, causing trouble and expense in the operation and maintenance of locomotives.

(3) Hard water can be softened by treatment with chemicals.

(4) The hardness of water due to carbonates of lime and magnesia can be removed by use of lime, a comparatively inexpensive chemical.

(5) The hardness of water due to sulphates of lime and magnesia can be removed by use of soda ash, a more expensive chemical. The chemical reaction leaves soluble sulphates of soda, increasing the tendency to foam.

(6) The removal of sulphate is more important than removal of

---

[7] Adopted, Vol. 9, 1908, pp. 110-112, 154; Vol. 11, Part 2, 1910, pp. 1143, 1144, 1219.

carbonates; the latter in absence of the former being precipitated in the boiler without forming hard scale.

(8) When use of hard water is necessary, study to determine the best method and the economical value of treating it should be made.

(9) The cost of installing a water-softening plant is determined by its capacity, prices of material and labor and locality.

(10) The cost of operating such a plant is determined by the efficiency of its apparatus and the cost and efficiency of chemicals, labor and supervision.

(11) The kind of chemicals required are determined by the quality and quantity of impurities in the water.

[8] WATER SOFTENERS.

(A) Design and Installation.

(1) Study should be made to determine the best method and economical value of treating the water, controlling conditions considered.

(2) Generally, installation of softening plants should follow a plan based on the operating division. Usually the complete equipment of one division will give better results than an equal number of plants scattered over a number of divisions.

(3) Whether or not the water can be successfully treated should be determined. Water sometimes contains solids of such character, combination and quantity that the water is unfit for use after treatment.

(4) The plant should have adequate capacity. Probable increase in water consumption should be anticipated.

(5) The mechanical apparatus should be simple in construction and operation, stable in adjustment and should accurately and uniformly introduce the chemicals into the water in necessary proportion.

(B) Operation, Maintenance and Supervision.

(1) Adequate and capable supervision, preferably by a chemist or engineer experienced or skilled in water treatment, is necessary to secure the best results.

(2) As a check on the treatment and to keep it properly adjusted to changes in the quality of the untreated water, frequent analyses of the water, treated and untreated, should be made by a competent chemist.

---

[8] Adopted, Vol. 8, 1907, pp. 604-607, 615, 617, 620, 621; Vol. 16, 1915, pp. 678, 1133.

(3) Where consumption of water is in excess of the effective capacity of the plant, the use of untreated, milky water should be avoided by the use of raw water to such an extent as to give ample time for the proper treatment of all water that passes through the softener. The exception to this rule is the case of water which is being treated for corrosive properties. Such water should not be used raw if it can be avoided.

(4) The reagents, as nearly as practicable, should be chemically pure.

(C) CAPACITY.

Where the lime and soda ash treatment is used, the volume of space for reaction and precipitation should be at least from three to four times the hourly capacity of the softener, depending on temperature and analysis of the water.

In continuous softeners, the capacity of the tank reserved for treatment and sedimentation should be not less than three to four times the hourly capacity of the plant, depending on the temperature of the water, low temperature requiring the larger capacity.

The determination of the number and volume of settling tanks for intermittent softeners depends on the number of pumps or batteries of pumps necessary to handle the water; time required to fill or empty each settling tank, above the sludge line, and time necessary for reaction and precipitation.

RELATIVE ECONOMY.

The relative economy of the different types of water softeners can be determined by comparing the total annual cost of each, exclusive of the cost of chemicals. This annual cost should be composed of:

(a) Interest on the sum of the cost of installation and value of ground space occupied;

(b) Depreciation;

(c) Current repairs;

(d) Increased cost of operating the water station due to additional labor and fuel required for the treatment.

REAGENTS.

The quantity of reagents required per unit of scaling or corroding substance held in solution, given in accompanying table, is recommended as good practice.

Where the commercial product is not chemically pure, the proportion of reagents should be increased to correspond with an equivalent quantity of pure reagent.

Given the analysis of a water, the pounds of incrusting or corrosive matter held in solution per 1000 gallons can be obtained by dividing the grains per gallon of each substance by seven, or the parts per 100,000 by twelve.

By using Table 1, the quantity of reagents per 1,000 gallons can be readily calculated, and by applying local cost of the same, the cost for chemicals per 1000 gallons will be obtained. In order to ascertain the full amount of lime necessary, the amount of free carbonic acid contained in the water should be determined, as well as the solids contained in solution, since this free acid must be eliminated in order to obtain efficient treatment of water and reduce scaling matter to the minimum.

TABLE 1. QUANTITY OF PURE REAGENTS REQUIRED TO REMOVE ONE POUND OF INCRUSTING OR CORROSIVE MATTER FROM THE WATER.

Incrusting or Corrosive Substance Held in Solution.	Amount of Reagent (Pure)	Foaming Matter Increased.
Sulphuric acid	0.57-lb. lime plus 1.08 lb. soda ash	1.45 lb.
Free carbonic acid	1.27 lb. lime	None
Calcium carbonate	0.56-lb. lime	None
Calcium sulphate	0.78-lb. soda ash	1.04 lb.
Calcium chloride	0.96-lb. soda ash	1.05 lb.
Calcium nitrate	0.65-lb. soda ash	1.04 lb.
Magnesium carbonate	1.33 lb. lime	None
Magnesium sulphate	0.47-lb. lime plus 0.88 lb. soda ash	1.18 lb.
Magnesium chloride	0.59-lb. lime plus 1.11 lb. soda ash	1.22 lb.
Magnesium nitrate	0.38-lb. lime plus 0.72 lb. soda ash	1.15 lb.
Calcium carbonate	3.15 lb. barium hydrate	None
Magnesium carbonate	3.76 lb. barium hydrate	None
Magnesium sulphate	2.62 lb. barium hydrate	None
*Calcium sulphate	2.32 lb. barium hydrate	None

* In precipitating the calcium sulphate, there would also be precipitated 0.74-lb. of calcium carbonate or 0.31-lb. of magnesium carbonate, the 2.32-lb. of barium hydrate performing the work of 0.41-lb. of lime and 0.78-lb. of soda ash, or for reacting on either magnesium or calcium sulphate, 1-lb. of barium hydrate performs the work of 0.18-lb. of lime plus 0.34-lb. of soda ash, and the lime treatment can be correspondingly reduced.

NOTE:—Table is based on use of calcium oxide or lump lime. To obtain equivalent value for hydrated lime, multiply lime value shown in table by 1.32.

[9] FOAMING AND PRIMING.

"Foaming" is the term applied to the action of a boiler when the steam bubbles up over the surface of the water to such extent that the steam space and dome are filled, and syphoning action is started which causes water to be carried over with the steam into the engine cylinders. Under these conditions steam loses much of its expansion properties and the effective operation of the locomotive is thereby materially impaired.

This action is due primarily to the presence of suspended matter in the water. The suspended matter gives a mechanical strength or tenacity to the liquid in the thin films over the steam bubbles, which, rising to the surface, retain their films and collect to produce foam. It is aggravated by the concentration of alkali salts present in the natural waters or added by the process of water softening, which increases the viscosity of the surface films.

---

[9] Adopted, Vol. 8, 1907, pp. 615, 616, 621; Vol. 16, 1915, 679, 1133; Vol. 20, 1919, pp. 280, 909.

The concentration of foaming salts reaches a critical point between 100 and 200 grains per gallon, depending upon the character of the alkali salts and the amount of suspended matter in the water. To prevent foaming the concentration must be kept below this point. The best results are obtained by the systematic and frequent blowing off of the boilers, and occasional complete blowing down and washing boilers at terminals. The cost of maintaining the concentration below the critical point equals the cost of pumping, treating, and heating to boiler temperature the amount of water necessary to be blown out.

When the unavoidable concentration of foaming salts is so great that the required amount of blowing off is impractical or uneconomical, anti-foaming compounds can be used with good results.

"Priming" is the sudden evolution of steam from a heating surface which throws water in sudden, large volumes up into steam space, and is due either to poor design of the boiler and to its being worked beyond capacity, or to the sudden opening of the throttle. While the effect upon the locomotive is temporarily the same, priming is different from foaming and can be mechanically controlled to large extent by proper handling of the engine.

[10] MINIMUM QUANTITY OF SCALING AND CORROSIVE MATTER WHICH WILL JUSTIFY TREATMENT.

The minimum quantity of solids in solution that will justify treatment depends on local conditions and the composition of the solids. By applying the proper local values to the equation given below, this quantity can be determined.

The following equation gives the point where the benefits derived from treating the water will balance the cost of treating:

X = Number cwt. (100 lb.) solids removed from water per annum.

B = Money value of benefits obtained from removing 100 lb. solids; this will include:

---

[10] Adopted, Vol. 8, 1907, pp. 612, 613, 616, 622.

Saving in boiler washing and repairs;

Saving in fuel.

Increased service obtained from locomotives, represented by the interest on the cost of the additional number of locomotives that would be required to perform the service rendered by locomotives using the soft water, if based on the performance prior to treating the water.

$C =$ Cost per 100 lb. of solids removed to operate the plant, as follows:

Additional cost of labor;

Additional cost of fuel or power;

Cost of chemicals;

Cost of current repairs.

$D =$ Cost of plant installed.

$I =$ Interest per annum on D.

$L =$ Estimated useful life of plant in years.

$R =$ Estimated value of materials recovered from plant after L years.

$S =$ Annual depreciation of plant, equivalent to a sum per year, which, if placed in a sinking fund at I rate of interest, would amount to $D—R$ in L years. (See table, page 16, Kent's Pocket Book.

The benefits would balance the cost when

$$XB = XC + I + S. \qquad (1)$$

$$X = \frac{I + S}{B - C} \qquad (2)$$

The number of pounds solids removed daily to make benefits equal the cost would be $\frac{I + S}{3.65\,(B - C)}$ (3)

If more than this amount of solids is removed the plant will be economical.

Values for B can only be fixed for each particular case, as some of the matter held in solution is more injurious than the same weight of other matter.

[11] WATER FOR DRINKING PURPOSES.

1. Federal Interstate Quarantine Regulations, section 13 to Amendment No. 8, as amended July 14th, 1919, and issued by the Public Health Service, provide that water for drinking purposes furnished by railroads

---

[11] Adopted, Vol. 21, 1920, pp. 56, 1348.

on cars in interstate traffic shall be pure and from a source which is approved as producing a water of satisfactory sanitary quality and safety.

2. It is preferable, where available at reasonable cost, that drinking water furnished by railroads should be secured from municipal supplies, as these, as a rule, secure close supervision from local and state health authorities.

3. Where impossible or impracticable to secure potable water from municipal source, precautions should be taken to provide against possible contamination. If supply is secured from wells, local drainage conditions should receive consideration and protection provided against this entering the wells. Surface supplies are particularly susceptible to contamination, and when used should receive standard treatment with bacteriacides such as calcium hypochlorite, chlorine, or ultra violet ray. All such supplies should be tested regularly and if found unfit should be posted with warning—"UNFIT TO DRINK."

[12] SPECIFICATIONS FOR WOODEN WATER TANK.

50,000 Gallons Capacity.

Material.

1. The tank, consisting of staves and bottom plank, shall be made of cypress, redwood, white pine, or such other timber as may be specified by the Engineer, and shall be sound, straight-grained, seasoned, out of wind, free from shakes, season checks, sap, pitch pockets or streaks, splits, rot, deadwood, unsound knots, loose knots, knots in clusters and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged with the same material as the tank. Material having knots in the edges will not be accepted. No plugs will be permitted within twelve (12) inches of the croze and no stave shall have more than one plug.

Size.

2. The tank shall be twenty-four (24) feet in diameter (inside measurement) and fifteen (15) feet eleven (11) inches high. (The height of tank to be the length of finished stave.)

Shape.

3. The tank shall be cylindrical the same diameter at top and bottom.

Bottom.

4. The bottom plank shall be eight (8) to twelve (12) inches wide

---

[12] Adopted, Vol. 21, 1920, pp. 71, 1349.

and three (3) inches thick jointed two edges, with three (3) inch chamfer to fit the croze. All pieces shall be full length without splicing. The bottom shall be cut to the true circle of the tank and the planks marked and numbered to indicate their correct position when the bottom is laid.

Staves.

(5) The staves shall be six (6) to eight (8) inches wide, and fifteen (15) feet eleven (11) inches long, of uniform width throughout with finished thickness of two and three-quarter (2¾) inches at edges of stave, the outer side of stave shall be surfaced to the true circle of the tank and edges accurately planed or sawed on radial lines from center of tank. The croze in each stave shall be four (4) inches in the clear from the end of the stave, the croze to be two and five-eighths (2⅝) inches wide with a five-eighths (⅝) inch gain and shall be accurately cut to fit true circle of bottom.

General.

6. (a) The tank shall be framed and jointed in such a manner that all joints may be made watertight without the use of any foreign material.

(b) The staves and bottom plank shall be fitted in a workmanlike manner before shipment, each piece plainly marked to indicate its proper position in the tank.

(c) At least one additional stave shall be shipped with each tank to provide against possible shrinkage or damage.

(d) To facilitate erection the staves may be provided with dowels placed one-third of length of stave from top, dowels to be three-quarter (¾) inch in diameter and of same material as stave.

100,000 Gallons Capacity.

Material.

1. The tank, consisting of staves and bottom plank, shall be made of cypress, redwood, white pine, or such other timber as may be specified by the Engineer, and shall be sound, straight-grained, seasoned, out of wind, free from shakes, season checks, sap, pitch pockets or streaks, splits, rot, deadwood, unsound knots, loose knots, knots in clusters and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged with the same material as the tank. Material having knots in the edges will not be accepted. No plugs will be permitted within twelve (12) inches of the croze and no stave shall have more than one plug.

Size.

(2) The tank shall be thirty (30) feet in diameter (inside measurement) and nineteen (19) feet eleven (11) inches high. (The height of tank to be the length of finished stave.)

Shape.

3. The tank shall be cylindrical, the same diameter at top and bottom.

Bottom.

4. The bottom plank shall be eight (8) to twelve (12) inches wide and three (3) inches thick jointed two edges, with three (3) inch chamfer. All plank twenty-four (24) feet or less in length shall be full length without splicing. Plank more than twenty-four (24) feet in length may be made in two pieces to be joined together by means of an iron tongue with suitable slots sawed in the ends of plank to receive the tongue, the tongue to be one-eighth (⅛) inch in thickness, six (6) inches long and the full width of stave. The bottom shall be cut to the true circle of the tank and the planks marked and numbered to indicate their correct position when the bottom is laid.

Staves.

5. The staves shall be six (6) to eight (8) inches wide and nineteen (19) feet eleven (11) inches long, of uniform width throughout, with finished thickness of three (3) inches at edge of stave. The outer side of stave shall be surfaced to the true circle of the tank and edges accurately planed or sawed on radial lines from center of tank. The croze in each stave shall be four (4) inches in the clear from the end of the stave, the croze to be two and five-eights (2⅝) inches wide with a five-eighth (⅝) inch gain and shall be accurately cut to fit true circle of bottom.

General.

6. (a) The tank shall be framed and jointed in such a manner that it may be made watertight without the use of any foreign material.

(b) The staves and bottom plank shall be fitted in a workmanlike manner before shipment, each piece plainly marked to indicate its proper position in the tank.

(c) At least one additional stave shall be shipped with each tank to provide against possible shrinkage or damage.

(d) To facilitate erection the staves may be provided with dowels placed one-third of length of stave from top; dowels to be three-quarter (¾) inch diameter and of same material as stave.

SPECIFICATIONS FOR TANK HOOPS.

Material.

The tank hoops shall preferably be wrought iron. They may be open-hearth steel. Such wrought iron or steel shall fulfill all of the requirements of quality, strength, inspection and test for wrought iron and open-hearth steel given in the General Specifications for Steel Railway Bridges in the recommended practice of the American Railway Engineering Association.

Shape.

2. Hoops to be round in cross-section the same size throughout and shall be bent to a true radius to fit the tank.

Size.

3. To be of such a size and so spaced that the stress shall not exceed 12,500 lb. per square inch, when computed from area at base of thread. No hoop less than three-quarter (¾) inch diameter to be used.

Spacing.

4. Spacing of hoops to be figured by the following formula:

$$\text{Spacing of hoops in inches} = \frac{\text{Safe load for given hoop in lb.}}{2.6 \text{ diameter (ft.)} \times \text{depth,* (ft.)}}$$

Top hoop to be placed within two inches of top of staves. No space between hoops to exceed 21 inches. Hoops to be so placed that lugs will not come in a vertical line.

On account of the swelling of the tank bottom the hoops near the bottom may be subjected to a strain greater than that due to the water pressure alone, therefore additional hoops should be provided. Two hoops of the size used next above it should be placed around the bottom opposite the croze, one of which shall not be considered as withstanding any water pressure.

Threads.

5. The ends of each section of hoop shall be threaded with U. S. standard thread for length of four and one-half (4½) inches.

Nuts.

6. Each end of each section shall be provided with two (2) hexagon nuts tapped to fit the thread on hoop.

Lugs.

7. The lugs shall be of standard pattern, at least eight (8) inches

---

*NOTE.—Depth refers to distance from top of stave to point where hoop is to be located.

long and as strong as the hoop; they shall preferably be made of malleable iron, but cast iron may be used if approved by the Engineer.

General.

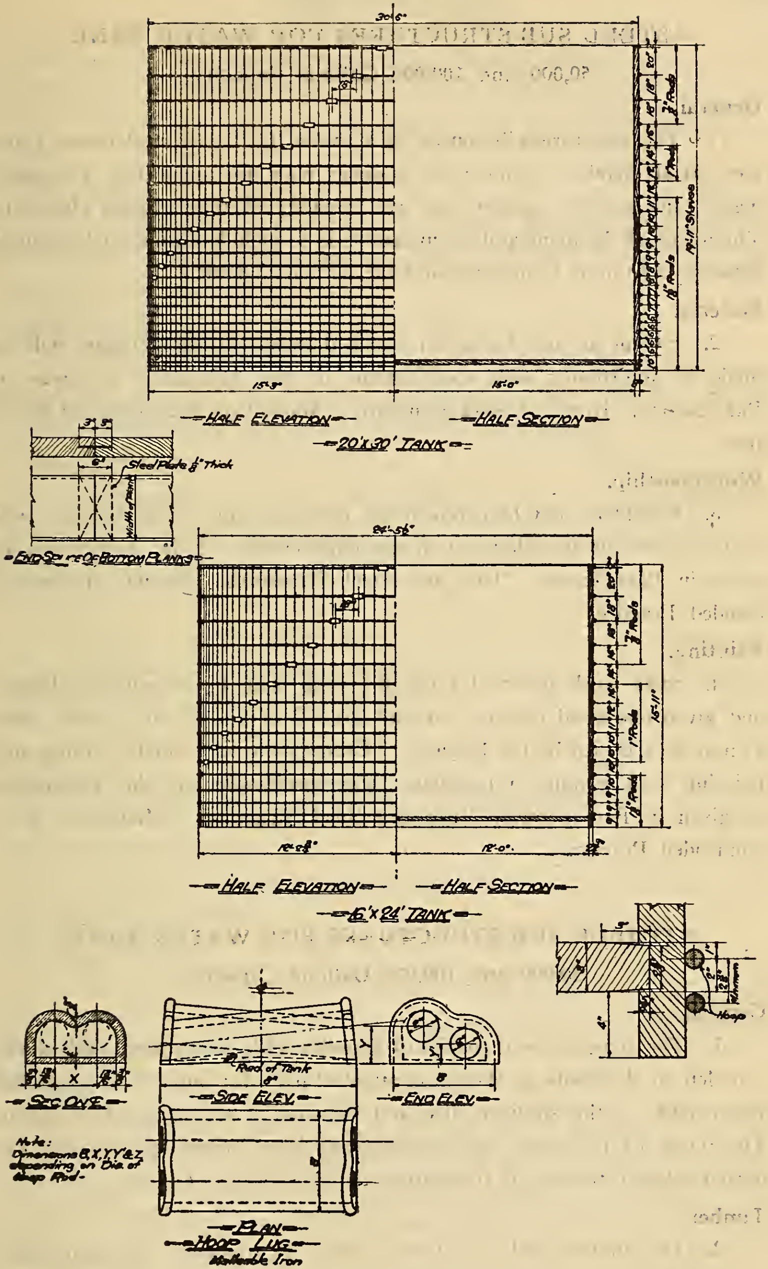
8. Each hoop shall be made in three (3) sections for sixteen by twenty-four (16 ft. by 24 ft.) foot tanks and in four (4) sections for twenty by thirty (20 ft. by 30 ft.) foot tanks.

The several pieces constituting one hoop shall be tied together for shipment.

All pieces shall be furnished in full lengths, unwelded, and must not vary from the lengths given on order more than one-half (½) inch.

Note.—Following table gives proper working strength for hoops of common sizes, based on the above allowable stress:

Diameter of Round Rod, Inches.	*Area of Section of Rod, Square Inch.*	*Net Area of Root of Thread, Square Inch.*	*Safe Working Load, Pounds.*
¾	.44	.30	3,750
⅞	.60	.42	5,250
1	.79	.55	6,875
1⅛	.99	.69	8,625



STANDARD 50,000 AND 100,000-GALLON WOODEN WATER TANK.

[13] STEEL SUB-STRUCTURES FOR WATER TANK.

50,000 and 100,000 Gallons Capacity.

General.

1. The structure will consist of a twelve (12) post steel tower, complete in all details, as shown on attached plan, for supporting a wooden water tank of the specified size and capacity at the required elevation. The intent of the plans and specifications is to include all material required between the top of foundation and the bottom of tank.

Material.

2. Except as may be herein noted all metal in the structure will be made in accordance with specifications of the Association as given in Part Second, "Iron and Steel Structures," Manual of Recommended Practice.

Workmanship.

3. Except as may be herein noted workmanship on the structure will be performed in accordance with the requirements of the Association as given in Part Second, "Iron and Steel Structures," Manual of Recommended Practice.

Painting.

4. Steel work before leaving the shop shall be thoroughly cleaned and given one good coat of red lead ground in linseed oil or such paint as may be specified by the Engineer. Except as herein noted, cleaning and painting shall be done in accordance with specifications of the Association as given in Part Second, "Iron and Steel Structures," Manual of Recommended Practice.

[14] TIMBER SUB-STRUCTURES FOR WATER TANK.

50,000 and 100,000 Gallons Capacity.

General.

1. The structure will consist of a twelve (12) post timber tank tower complete in all details, as shown on attached plan, for supporting a wooden water tank of the specified size and capacity at the required elevation. The intent of the plans and specifications is to include all material required between the top of foundation and the bottom of tank.

Timber.

2. The timber shall be cypress, pine, fir, redwood, or such other

---

[13] Adopted, Vol. 22, 1921, pp. 434, 1021.

[14] Adopted, Vol. 22, 1921, pp. 435, 1021.

timber as may be specified by the Engineer, S. 4 S. and conforming to the specifications of this Association for No. 1 railroad bridge timber, as given in "Wooden Bridges and Trestles," Manual of Recommended Practice.

Workmanship.

3. All workmanship shall be in accordance with "Specifications for Workmanship for Pile and Frame Trestles to Be Built Under Contract," Manual of Recommended Practice.

Metal Details.

4. All metal details shall conform to the specifications of the Association as given in "Specifications for Metal Details Used in Wooden Bridges and Trestles," Manual of Recommended Practice.

Painting.

5. All exposed woodwork shall be painted with one priming and two finishing coats of such paints and colors as may be specified by the Engineer.

Treating.

6. Where treated timber is used timber shall be treated with creosote oil in accordance with the requirements of Committee on Wood Preservation, Manual of Recommended Practice.

[15] SPECIFICATIONS FOR STEEL WATER AND OIL TANKS.

Scope of Specifications.

1. These specifications are intended for steel tanks requiring plates not more than ⅝-inch thick.

Quality of Metal.

2. The metal in these tanks shall be open-hearth steel. The steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

Loading.

3. The weight of water shall be assumed to be 63 lbs., crude oil 56 lbs., and creosote oil 66 lbs. per cubic foot. Wind pressure, acting in any direction, shall be assumed to be, in pounds, thirty times the product of the height by two-thirds of the diameter of the tank in feet.

Unit Stresses.

4. Unit stresses shall not exceed the following:

---

[15] Adopted, Vol. 13, 1912, pp. 417-419, 984-988.

(a) Tension in plates, 15,000 lbs. per square inch on net section.

(b) Shear in plates, 12,000 lbs. per square inch on net section.

(c) Shear on rivets, 12,000 lbs. per square inch on net section.

(d) Bearing pressure on field rivets, 20,000 lbs. per square inch.

Cylindrical Rings.

5. Plates forming the shell of the tank shall be cylindrical and of different diameters, in and out, from course to course.

Workmanship.

6. Workmanship shall be first-class. Plates shall be beveled on all edges for caulking after being punched. The punching shall be from the surface to be in contact. The plates shall be formed cold to exact form after punching and beveling. Rivet holes shall be accurately spaced. Drift pins shall be used only for bringing the parts together. They shall not be driven with enough force to deform the metal about the holes. Power riveting and caulking should be used. A heavy yoke or pneumatic bucker shall be used for power-driven rivets. Riveting shall draw the joints to full and tight bearing.

Caulking.

7. The tank shall be made water or oil tight by caulking only. No foreign substance shall be used in the joints. For water tanks, the caulking shall preferably be done on the inside of tank and joint only; but for oil tanks the caulking should be done on both sides. No form of caulking tool or work that injures the abutting plate shall be used.

Minimum Thickness of Plates.

8. The minimum thickness of plates in the cylindrical part of the tank shall be not less than ¼-inch and in flat bottoms not less than $\frac{5}{16}$-inch. In curved bottoms the thickness of plate shall be not less than that of the lower plate in the cylindrical part.

Horizontal and Radial Joints.

9. Lap joints shall generally be used for horizontal seams and splices and for radial seams in curved bottoms.

Vertical Joints.

10. For vertical seams and splices, lap joints shall be used with plates not more than ⅜ inch thick. With thicker plates, double butt joints with inside and outside straps shall generally be used. The edge of the plate in contact at the intersection of horizontal and vertical lap joints shall be drawn out to a uniform taper and thin edge.

Rivets, Rivet Holes, Punching and Pitch.

11. For plates not more than 3/8 inch thick, 5/8-inch rivets shall be used. For thicker plates, 3/4-inch rivets shall be used. The diameter of rivet holes shall be 1/16-inch larger than the diameter of the rivets used. The punching shall conform to the specifications of this Association for such work on steel bridges. A close pitch, with due regard for thickness of plate and balanced stress between tension on plates and shear on rivets, is desirable for caulking.

Tank Support.

12. If the tank is supported on a steel substructure, the latter shall conform to the specifications of this Association for the manufacture and erection of steel bridges, except that allowance shall be made for wind pressure, but not for impact.

Painting.

13. In the shop the metal shall be cleaned of dirt, rust and scale and, except the surfaces to be in contact in the joints of the tank, shall be given a shop coat of paint or metal preservative selected and applied as specified by the Company.

After being completely erected, caulked and cleaned of dirt, rust and scale, all exposed metal work shall be painted or treated with such coat or coats of paint or metal preservative as shall be selected by the Railway Company.

Plans and Specifications.

14. Under these specifications and in conformity thereto the Railway Company shall cause to be prepared or shall approve detail plans and specifications for tanks, herein specified, as it shall construct. Such plans and specifications shall cover all necessary tank auxiliaries.

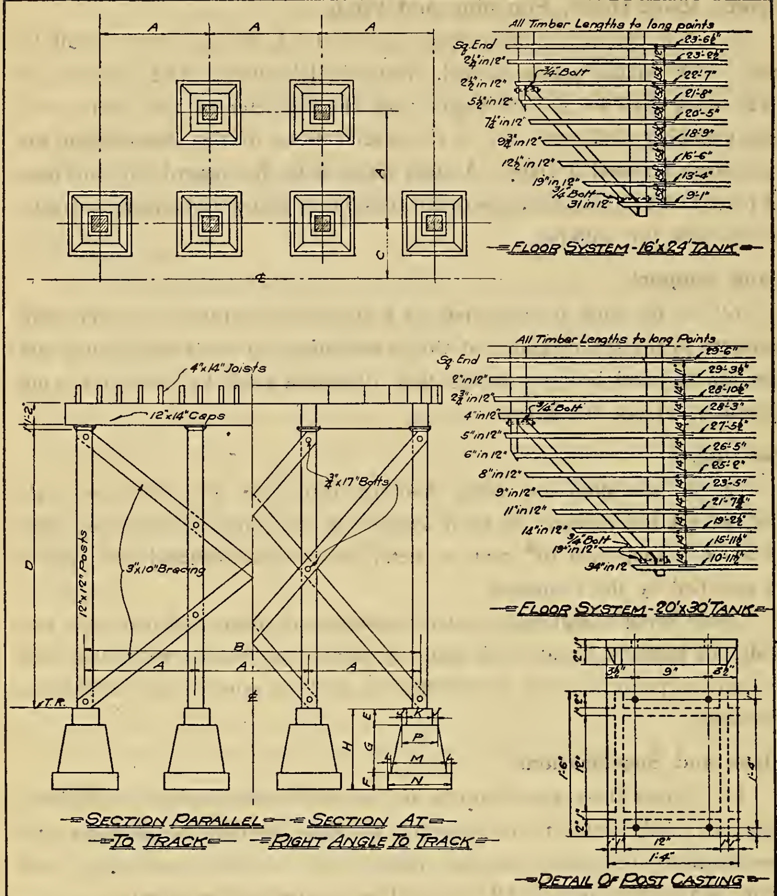
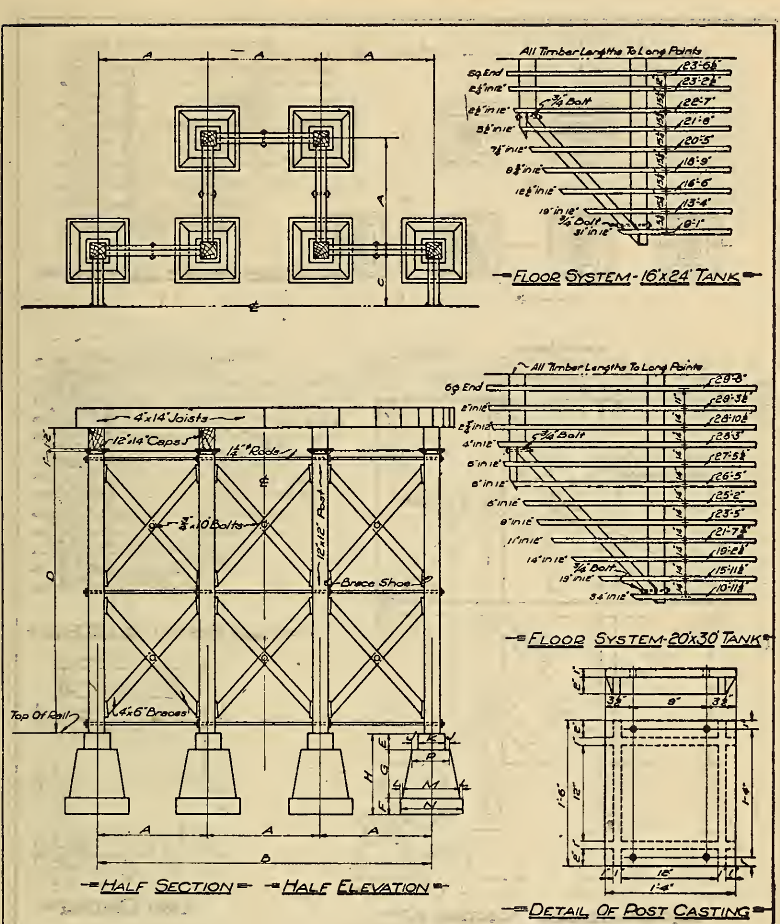


TABLE OF DIMENSIONS & SIZES				
Mark Or Description	SIZE OF TANK			
	16'x24'		20'x30'	
	16' Tower	20' Tower	16' Tower	20' Tower
A	6'-11"	6'-11"	8'-6"	8'-6"
B	20'-9"	20'-9"	25'-6"	25'-6"
C	3'-5½"	3'-5½"	4'-3"	4'-3"
D	13'-5"	17'-5"	13'-5"	17'-5
E	1'-0"	1'-0"	1'-0"	1'-0"
F	1'-0"	1'-0"	1'-6"	1'-6"
G	3'-0"	3'-0"	3'-6"	3'-6"
H	5'-0"	5'-0"	6'-0"	6'-0"
J	0'-5"	0'-5"	0'-5"	0'-5"
K	1'-8"	1'-8"	1'-8"	1'-8"
L	0'-3"	0'-3"	0'-3"	0'-3"
M	3'-6"	3'-6"	4'-6"	4'-6"
N	4'-0"	4'-0"	5'-0"	5'-0"
P	2'-6"	2'-6"	2'-6"	2'-6"
Posts	12"x12"	12"x12"	12"x12"	12"x12"
Braces	3"x10"	3"x10"	3"x10"	3"x10"
Bolts	¾"x17"	¾"x17"	¾"x17"	¾"x17"

NOTE:—
The footing detail as given represents an average condition
Measurement "N" will be governed by soil conditions but in no case to exceed 3000#/□'

—STD. TIMBER 12 POST WATER TANK TOWER—
—DIAGONAL PLANK BRACING—
—FOR 16'X24' & 20'X30' TANKS—
—16'-0" & 20'-0" HEIGHTS—

Scale - None Sept 16, 1920



FLOOR SYSTEM - 16'x24' TANK

FLOOR SYSTEM - 20'x30' TANK

HALF SECTION — HALF ELEVATION

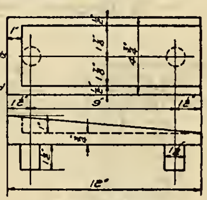
DETAIL OF POST CASTING

TABLE OF DIMENSIONS & SIZES				
Mark Or Description	SIZE OF TANK			
	16'x24'		20x30'	
	16' Tower	20' Tower	16' Tower	20' Tower
A	6'-11"	6'-11"	8'-6"	8'-6"
B	20'-9"	20'-9"	25'-6"	25'-6"
C	3'-5½"	3'-5½"	4'-3"	4'-3"
D	13'-5"	17'-5"	13'-5"	17'-5"
E	1'-0"	1'-0"	1'-0"	1'-0"
F	1'-0"	1'-0"	1'-6"	1'-6"
G	3'-0"	3'-0"	3'-6"	3'-6"
H	5'-0"	5'-0"	6'-0"	6'-0"
J	0'-5"	0'-5"	0'-5"	0'-5"
K	1'-8"	1'-8"	1'-6"	1'-8"
L	0'-3"	0'-3"	0'-3"	0'-3"
M	3'-6"	3'-6"	4'-6"	4'-6"
N	4'-0"	4'-0"	5'-0"	5'-0"
P	2'-6"	2'-6"	2'-6"	2'-6"
Posts	12"x12"	12"x12"	12"x12"	12"x12"
Braces	4"x6"	4"x6"	4"x6"	4"x6"
Bolts	¾"x10"	¾"x10"	¾"x10"	¾"x10"
Rods	1¼"x8'-4"	1¼"x8'-4"	1¼"x8'-11"	1¼"x9'-11"

NOTE:-

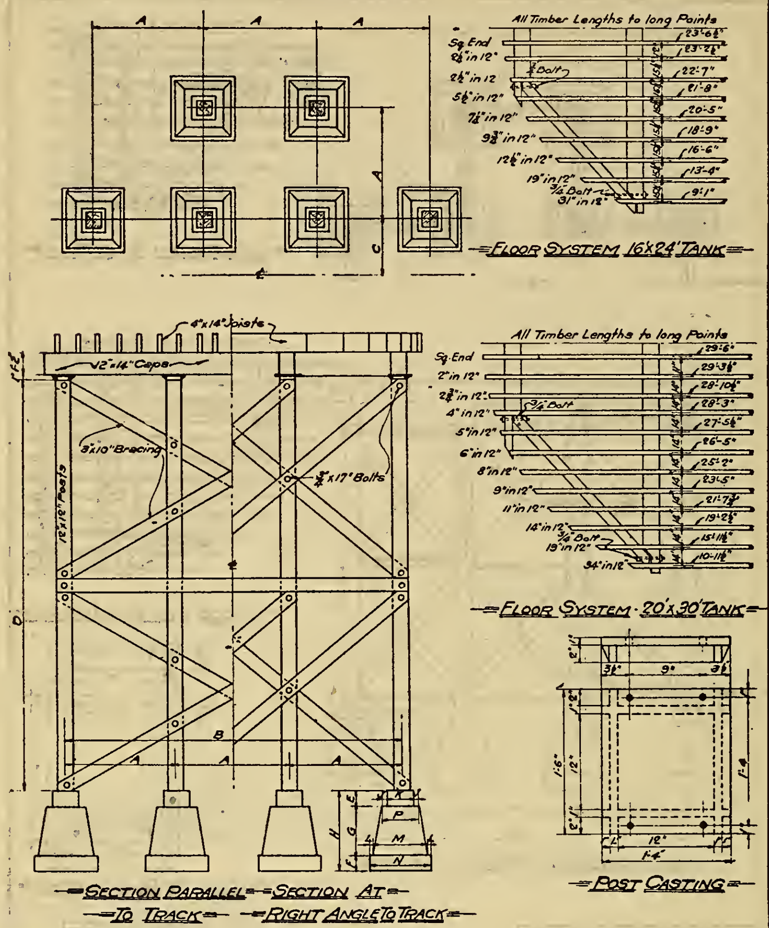
The footing detail as given represents an average condition.

Measurement "N" will be governed by soil conditions but in no case to exceed 3000#/□'



BRACE SHOE

STD. TIMBER 12 POST WATER TANK TOWER
DIAGONAL STRUT BRACING.
FOR 16'x24' & 20'x30' TANKS
16'-0" & 20'-0" HEIGHTS
Scale: None — Sept. 16, 1920.



FLOOR SYSTEM 16'x24' TANK

FLOOR SYSTEM · 20'x30' TANK

POST CASTING

SECTION PARALLEL TO TRACK

SECTION AT RIGHT ANGLE TO TRACK

TABLE OF DIMENSIONS		
Mark or Description	30'-0" TOWER SIZE OF TANK	
	16'x24'	20'x30'
A	6'-11"	8'-6"
B	20'-9"	25'-6"
C	3'-5½"	4'-3"
D	27'-5"	27'-5"
E	1'-0"	1'-0"
F	1'-0"	1'-6"
G	3'-0"	3'-6"
H	5'-0"	6'-0"
J	0'-5"	0'-5"
K	1'-8"	1'-8"
L	0'-3"	0'-3"
M	3'-6"	4'-6"
N	4'-0"	5'-0"
P	2'-6"	2'-6"
Posts	12"x12"	12"x12"
Braces	3"x10"	3"x10"
Bolts	¾"x17"	¾"x17"

Note:-

The footing detail as given represents an average condition.

Measurement "N" will be governed to soil conditions but in no case to exceed 3000#/□"

STD. TIMBER 12 POST WATER TANK TOWER
DIAGONAL PLANK BRACING
FOR 16'x24' & 20'x30' TANKS
30'-0" HIGH

Scale - None   Sept. 17, 1920

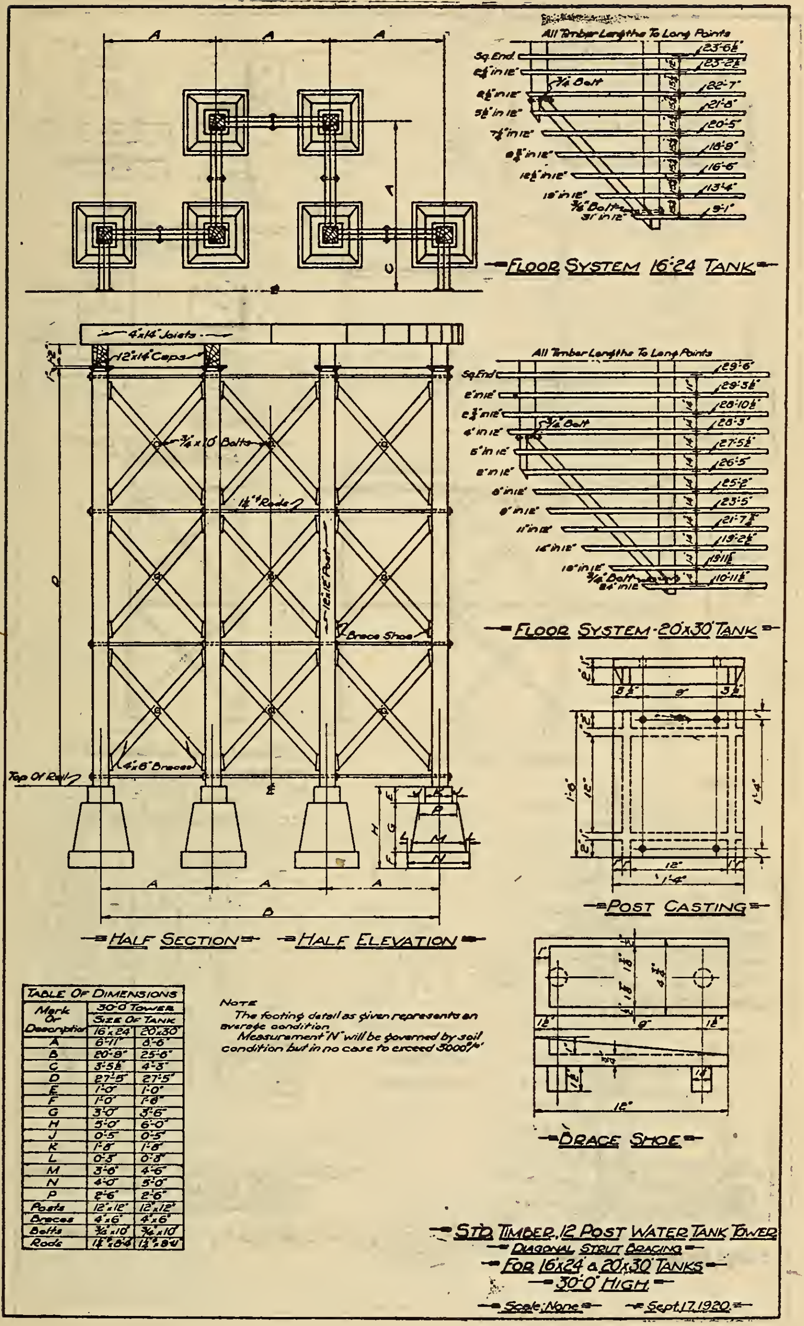


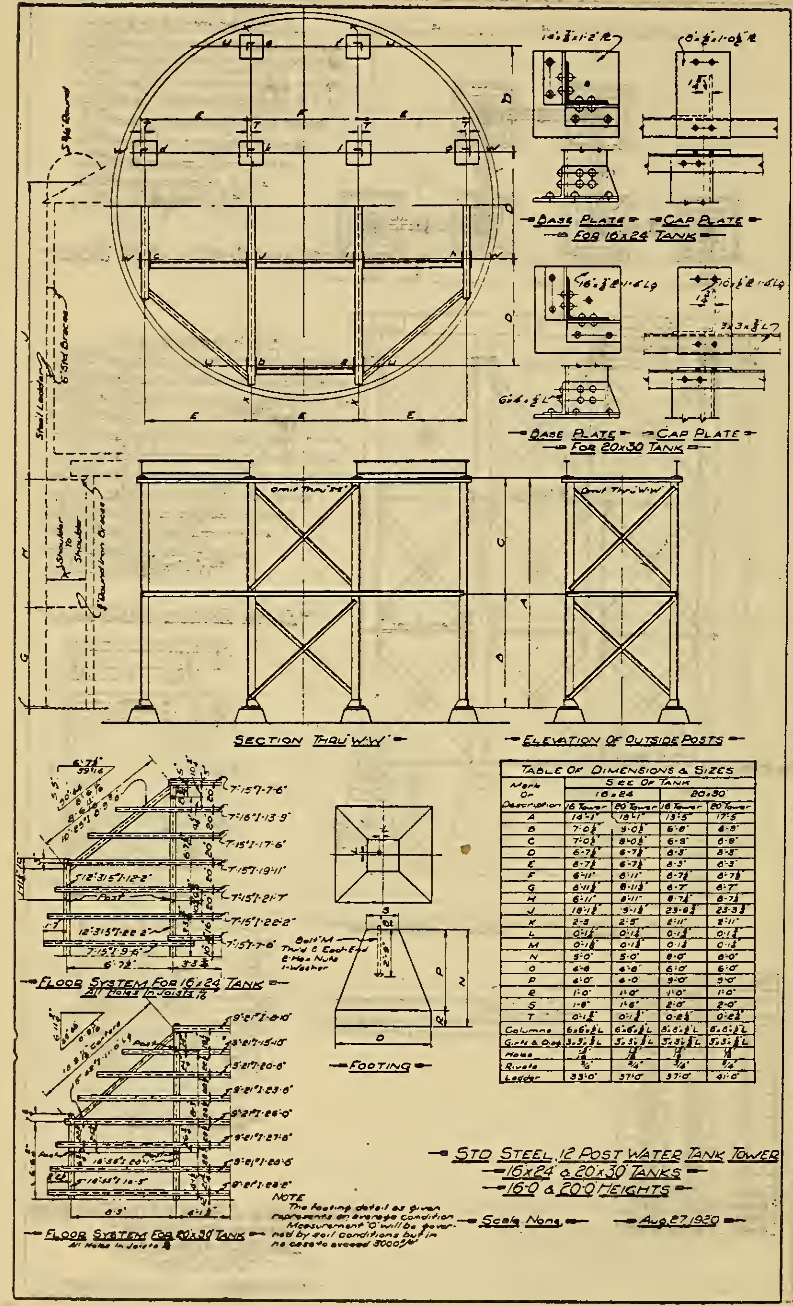
TABLE OF DIMENSIONS		
Mark Or Description	30'-0" TOWER	
	SIZE OF TANK	
	16'x24'	20'x30'
A	6'-11"	8'-6"
B	20'-8"	25'-6"
C	3'-5½"	4'-3"
D	27'-5"	27'-5"
E	1'-0"	1'-0"
F	1'-0"	1'-8"
G	3'-0"	3'-6"
H	5'-0"	6'-0"
J	0'-5"	0'-5"
K	1'-8"	1'-8"
L	0'-5"	0'-8"
M	3'-6"	4'-6"
N	4'-0"	5'-0"
P	2'-6"	2'-6"
Posts	12"x12"	12"x12"
Braces	4"x6"	4"x6"
Bolts	¾"x10"	¾"x10"
Rods	1¼"x8'-6"	1¼"x8'-4"

NOTE

The footing detail as given represents an average condition.

Measurement "N" will be governed by soil condition but in no case to exceed 3000#/⁰'

STD. TIMBER, 12 POST WATER TANK TOWER
DIAGONAL STRUT BRACING
FOR 16'x24' & 20'x30' TANKS
30'-0" HIGH
Scale: None
Sept. 17, 1920.


BASE PLATE
CAP PLATE
FOR 16'x24' TANK
BASE PLATE
CAP PLATE
FOR 20'x30' TANK
SECTION THRU W-W
ELEVATION OF OUTSIDE POSTS
Omit Thru "W-W"
Steel Ladder
6" Std Braces
Shoulder To Shoulder
¾" Round Iron Braces
FLOOR SYSTEM FOR 16'x24' TANK
All Holes In Joists 13/16
FLOOR SYSTEM FOR 20'x30' TANK
All Holes In Joists 13/16
FOOTING
Bolt "M" Thrd & Each End 2-Hex Nuts 1-Washer
Post

STD STEEL 12 POST WATER TANK TOWER
16'x24' & 20'x30' TANKS
16'-0" & 20'-0" HEIGHTS

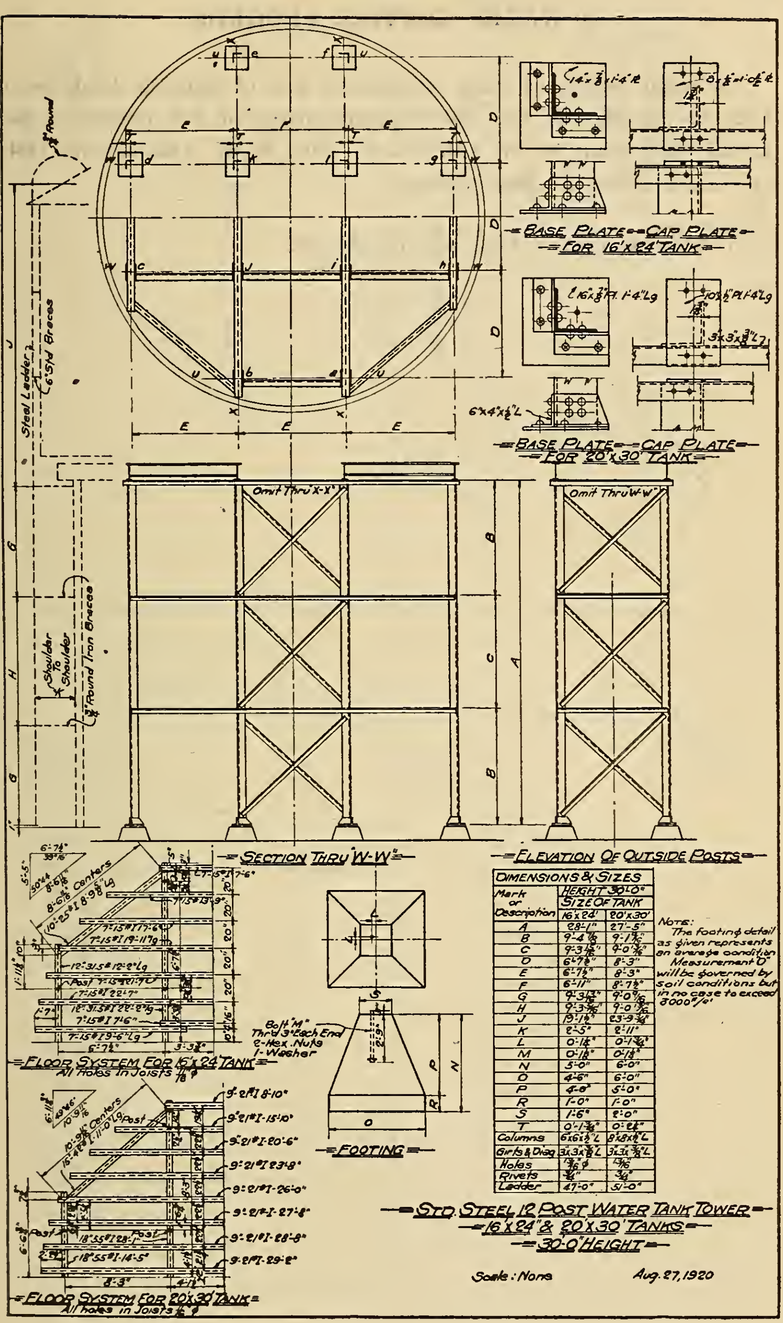
Scale None

Aug 27 1920

NOTE
The footing detail as given represents an average condition. Measurement "O" will be governed by soil conditions but in no case to exceed 3000#/ft²

TABLE OF DIMENSIONS & SIZES

Mark or Description	Size of Tank 16x24 16' Tower	16x24 20' Tower	20x30' 16' Tower	20x30' 20' Tower
A	14'-1"	18'-1"	13'-5"	17'-5"
B	7'-0½"	9'-0½"	6'-8"	6'-8"
C	7'-0½"	9'-0½"	6'-9"	6'-9"
D	6'-7½"	6'-7½"	8'-3"	8'-3"
E	6'-7½"	6'-7½"	8'-3"	8'-3"
F	6'-11"	6'-11"	6'-7½"	6'-7½"
G	6'-11½"	6'-11½"	6'-7"	6'-7"
H	6'-11"	6'-11"	8'-7½"	8'-7½"
J	18'-1½"	19'-1½"	23'-0¾"	23'-3¾"
K	2'-5"	2'-5"	2'-11"	2'-11"
L	0'-1½"	0'-1½"	0'-1½"	0'-1½"
M	0'-1⅝"	0'-1⅝"	0'-1⅝"	0'-1⅝"
N	5'-0"	5'-0"	8'-0"	8'-0"
O	4'-6"	4'-6"	6'-0"	6'-0"
P	4'-0"	4'-0"	9'-0"	9'-0"
R	1'-0"	1'-0"	1'-0"	1'-0"
S	1'-6"	1'-6"	2'-0"	2'-0"
T	0'-1½"	0'-1½"	0'-2½"	0'-2½"
Columns	6×6×½ L	6×6×½ L	8×8×½ L	8×8×½ L
Girts & Diag.	3×3×⅜ L	5×3×⅜ L	5×3×⅜ L	5×3×⅜ L
Holes	13/16"	13/16"	13/16"	13/16"
Rivets	¾"	¾"	¾"	¾"
Ladder	33'-0"	37'-0"	37'-0"	41'-0"



DIMENSIONS & SIZES		
Mark or Description	HEIGHT 30'-0" SIZE OF TANK	
	16'x24'	20'x30'
A	28'-1"	27'-5"
B	9'-4 1/8"	9'-1 7/16"
C	9'-3 15/16"	9'-0 7/16"
D	6'-7 1/2"	8'-3"
E	6'-7 1/2"	8'-3"
F	6'-11"	8'-7 1/2"
G	9'-3 13/16"	9'-0 9/16"
H	9'-3 5/16"	9'-0 7/16"
J	19'-1 1/2"	23'-9 3/4"
K	2'-5"	2'-11"
L	0'-1 1/8"	0'-1 3/4"
M	0'-1 1/8"	0'-1 1/8"
N	5'-0"	6'-0"
O	4'-6"	6'-0"
P	4'-0"	5'-0"
R	1'-0"	1'-0"
S	1'-6"	2'-0"
T	0'-1 3/4"	0'-2 1/4"
Columns	6"x6"x1/2" L	8"x8"x1/2" L
Girts & Diag	3"x3"x3/8" L	3"x3"x3/8" L
Holes	13/16" φ	13/16"
Rivets	3/4"	3/4"
Ladder	47'-0"	51'-0"

NOTE:
The footing detail as given represents an average condition. Measurement "O" will be governed by soil conditions but in no case to exceed 3000#/□'

STD. STEEL 12 POST WATER TANK TOWER
16'x24' & 20'x30' TANKS
30'-0" HEIGHT

Scale: None Aug. 27, 1920

[16] WATER SERVICE RECORDS.

Accurate records of water stations and costs of pumping should be at hand in the office of the official having charge of this branch of the service, and forms M. W. 1301, M. W. 1302, M. W. 1303, M. W. 1304, are recommended for this purpose.

---

[16] Adopted, Vol. 10, 1909, pp. 776, 780, 821.

Form 1301.

PUMPER'S DAILY REPORT.

3 Inches X 3 Inches

Railway Business

ADDRESS OF OFFICIAL

(Folding Line)

INSTRUCTIONS

Each pumper will fill out one of these reports each day for each plant worked at and forward to

....

(Name of official)

In the supply report fill in the column headed "Balance on hand last day of month" only on the report for the last of the month, showing the supplies on hand at the close of the work on the last day of the month.

5½ Inches ADDRESS SIDE

Size of Card 5½ x 6 inches, printed both sides.

PUMPING REPORT

	Hour.	Min.	Hour.	Min.	Hour.	Min.
Time started..						
Time stopped.						
Time ran......						

Counter at start..			
Counter when stopped.			
Dif'rence counter.			
Gage at start..			
Gage when stopped.			
Average gage.....			

(Folding Line)

Pounds Coal used........................

Gallons Gasoline used...................

Other Fuel used.........................

STATION..............................

Date........................19....

Supplies Received		Balance on Hand Last Day of Month
Received To-day		
	Kind Tons Coal	
	Gal. Gasoline	
	Qt. Gas Eng. Oil	
	Qt. Cylinder Oil	
	Qt. Car Oil	
	Qt. Oil	
	Lbs. Waste	

Pumper

5½ Inches REPORT SIDE

Form 1302.

STATEMENT OF COST OF PUMPING WATER

STATION	DATE	TIME PUMP RAN		No Rev. of Counter	Gallons Per Rev	GALLONS PUMPED		Gage Press. in Feet	H.P. = Gal. per Min. × Head Feet ÷3960	FUEL REPORTED AS USED			SUPPLIES RECEIVED																COST RECORD INCLUDING LABOR				
													Coal @ $		Gasoline @ $		Other Fuel		Gas Engine Oil @		Cylinder Oil @		Car Oil @		Other Oil @		Waste @						
		Hr.	Min.			Total	Per Min.			Coal Pounds	Gasoline Gallons	Other Fuel	Tons	Cost	Gal.	Cost		Cost	Qts.	Cost	Qts.	Ccst	Qts.	Ccst	Qts.	Cost	Lbs.	Cost	Labor Cost	Total Mtl.	Per 1000 Gal.	Per Hour	Per H.P. Hour

Form 1303.

WATER STATION RECORD

AT__________________________

WHERE PAINTING RECORD IS DESIRED ENTER DATE PAINTED WITH PREFIX "P" IN DATE COLUMN.

WHERE SECOND-HAND EQUIPMENT IS INSTALLED ENTER DATE OF MANUFACTURE IN BRACKETS OVER INSTALLATION DATE.

WATER TANKS, SETTLING TANKS INCLUDED							
			Tub				
Date	Foundation	Substruct.	Diam.	Hght.	Capacity Gallons	Frost Box	Plan Reference

WATER COLUMN									
	Pit				Column				
Date	Width	Lght.	Depth	Matl.	Kind	Col. Diam.	Col. Supply	C.Col. Toc.Tk	Top Rail to Bot.Spout

PUMP HOUSE						
Date	Width	Length	Sill to Plate	Foundation	Above Found.	Roof

PUMP PIT			
Date	Size	Depth	Material

WIND MILLS					
Tower			Wheel		
Date	Kind	Hght.	Date	Kind	Diam.

BOILERS												
	Boiler							Stack			Injector	
				Shell								
Date Installed	Shop No.	Name Maker	Kind	Lgth.	Diam.	Size Grate	No. & Size Flues	Date	Diam.	Height	Size	Kind

PUMPS								
						Size		
Date	Maker and Shop Number	Kind of Power	Simplex or Compound Expansion	Single or Double Action	No. of Water Cylinders	Steam	Water	Stroke

ENGINES				
Date	Maker and Shop Number	Kind	Rated H.P.	Connections from Engine to Pump

TREATING PLANTS	
Date	Maker and Plan Reference

WATER SUPPLY													
		Dug Wells				Pipe Wells							
		Diam.						Diam.					
Date	Source	Top	Bottom	Total Depth	Material	Date	Number	Top	Bottom	Total Depth	Working Barrel Below Top Well	Kind Point, Screen or Strainer	Make of Packing Head

HEIGHTS		
Top Tank to		
High Water	Low Water	Center Pump

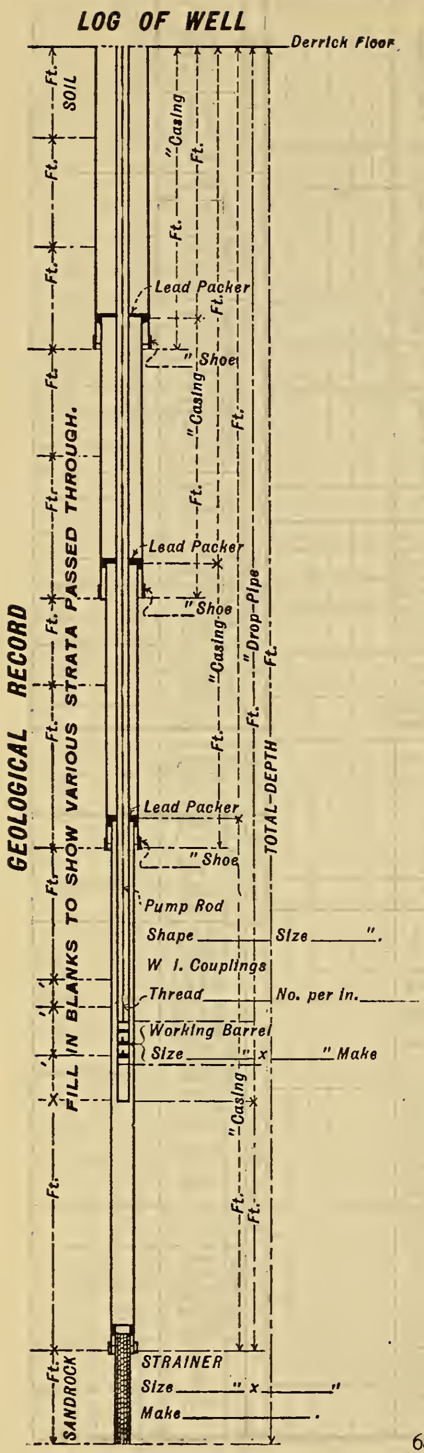
ANALYSIS	
Lbs. incrust. Solids per 1000 gal.	Fitness for Engine Use

PIPE LINES SEE ____________ FOR LOCATION																		
Steam			Exhaust			Suction			Discharge			Column Supply			Other Lines			
Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Use	Length

COST RECORD		
Date	Work Done	Original Construction Cost

Form 1304.

RECORD OF DEEP WELLS.



Location ....

Date began drilling.............. . ....

Well completed ....

WATER LEVELS.

Water stands at.............. .... ..ft

And pumps down to.............. ..ft.

When delivering .... gals per minute.

COMMITTEE XIV.

YARDS AND TERMINALS.

[1] DEFINITIONS.

Terminals.

Terminal.—An assemblage of facilities provided by a railway at a terminus or at intermediate points on its line for the purpose of assembling, assorting, classifying and relaying trains.

Freight Terminal.—The arrangement of terminal facilities for the handling of freight traffic.

Passenger Terminal.—The arrangement of terminal facilities for the handling of passenger traffic.

Yards.

Yard.—A system of tracks within defined limits provided for making up trains, storing cars, and other purposes, over which movements not authorized by timetable or by train-order may be made, subject to prescribed signals, rules and regulations.

Receiving Yard.—A yard for receiving trains.

Separating Yard.—A yard adjoining a receiving yard, in which cars are separated according to district, commodity or other required order.

Classification Yard.—A yard in which cars are classified or grouped in accordance with requirements.

Departure or Forwarding Yard.—A yard in which cars are assembled in trains for forwarding.

Storage Yard.—A yard in which cars are held awaiting disposition.

Holding Yard.—A convenient relief yard for holding cars or trains for immediate use.

Gravity Yard.—A yard in which the classification of cars is accomplished by gravity.

Coach Yard.—A yard in which passenger train cars are assembled, classified or prepared for service.

Assisting Grade.—The inclination given to tracks of a yard to facilitate the movement of cars.

---

[1] Adopted, Vol. 2, 1901, pp. 39, 40, 46-59; Vol. 4, 1903, p. 349; Vol. 5, 1904. pp. 221, 224-226; Vol. 6, 1905, pp. 568-570, 575, 592; Vol. 7, 1906, pp. 153-155; Vol. 11, Part 2, 1910, pp. 1257, 1258, 1309, 1310; Vol. 12, Part 1, 1911, pp. 235. 263; Vol. 16, 1915, pp. 958, 1190.

POLING YARD.—A yard in which the movement of cars is accomplished by the use of a pole operated by an engine on an adjacent parallel track.

SUMMIT OR HUMP YARD.—A yard in which the movement of cars is accomplished by pushing them over a summit, beyond which they run by gravity.

TRACKS.

BODY TRACK.—Each of the parallel tracks of a yard, upon which cars are switched or stored.

LADDER TRACK.—A track connecting successively the body tracks of a yard.

LEAD TRACK.—An extended track connecting either end of a yard with the main track.

INTERCHANGE TRACK.—A designated track on which cars are delivered or received, as between railroads.

DRILL TRACK.—A track connecting with the ladder track and used for movements in yard switching.

RUNNING TRACK.—A track reserved for movement through a yard.

CROSSOVER TRACK.—A track connecting two adjacent tracks.

RELIEF TRACK.—An extended siding long enough to allow an inferior train to continue running.

STUB TRACK.—A track connected with another one at one end only.

SPUR TRACK.—A stub track of indefinite length diverging from a main line or track.

HOUSE TRACK.—A track alongside of (or entering) a freight house, and used for cars receiving or delivering freight at the house.

SWITCHING DISTRICT.—That portion of a railway at a large terminal into which cars are moved, and from which they are distributed to the various sidetracks and spurs to freight houses and manufacturing establishments served from this district by yard or switching engines.

INDUSTRIAL TRACK.—A track serving one or more industries.

TEAM TRACK.—A track where freight is transferred directly between cars and wagons.

NOTE.—In a typical yard there will be several tracks, devoted to special purposes, varying with local conditions. These will include caboose tracks, scale tracks, coaling tracks, ashpit tracks, bad order tracks, repair tracks, icing tracks, feed tracks, stock tracks, transfer tracks, sand tracks, depressing tracks, etc.

RAIL AND WATER TERMINAL.—A terminal where freight is transferred between railway cars and boats.

Wye.—A triangular arrangement of tracks used for turning engines, cars or trains.

Transfer Slip.—A protected landing place for transfer boats with adjustable apron or bridge for connecting tracks on the land with those on the transfer boats.

Incline.—An inclined track (or tracks) at a protected landing place, with adjustable apron and cable for connecting to the tracks on a transfer boat.

Siding.—A track auxiliary to main track for meeting or passing trains, limited to the distance between two adjacent telegraph stations.

Piers.

Lighterage Pier.—An open or covered pier at which freight is transferred directly between cars and boats.

Export Pier.—A pier at which freight is unloaded and stored, mainly for shipment on ocean or coasting vessels.

Station Pier.—A pier having no rail connections, where freight is received and delivered by transfer boats.

Coal Pier.—An open pier where coal is transferred from cars to vessels or barges.

[2] GENERAL REQUIREMENTS OF YARDS AND TERMINALS.

Body Tracks.

Under ordinary conditions body tracks should be spaced 13 feet to 14 feet center to center, and where they are parallel to main track or other important running track, the first body track should be spaced not less than 15 feet center to center from such main or other important track.

Ladder Tracks.

These should be spaced not less than 15 feet center to center from any parallel track. Frogs of greater angle than No. 8 should not be generally used, and the angle between the ladder track and body tracks will be governed by the distance on ladder track required for a turnout.

Lead Tracks.

To facilitate train movements the connections of these tracks with the main track should be interlocked. To facilitate and protect train movements means of direct communication should be established.

---

[2] Adopted, Vol. 2, 1901, pp. 43-45; Vol. 3, 1902, pp. 267, 268, 280-288; Vol. 4, 1903, pp. 370-380; Vol. 5, 1904, pp. 182-184, 221-224; Vol. 6, 1905, pp. 570-574, 583, 592-594; Vol. 11, Part 2, 1910, pp. 1258, 1259, 1309; Vol. 12, Part 1, 1911, pp. 236, 264; Vol. 16, 1915, pp. 958, 1190.

Drill Tracks.

Drill tracks should be so located as to cause least possible interference with other movements.

Running Tracks.

Running tracks should be provided for movements in either direction to enable yard engines to pass freely from one position of the yard to the other; also to enable road and yard engines to pass to and from the engine house and other points where facilities are provided.

Crossover Tracks.

Crossover tracks should be located at most convenient points where they will least interfere with regular movements.

Caboose Tracks.

Where conditions permit, caboose tracks should be so located that cabooses can be placed on and removed from them in the order of their arrival, and should be so constructed that cabooses can be dropped by gravity onto the rear of trains made up for departure.

Scale Tracks.

Scale tracks should be so located that weighing can be done with least delay and without drilling over scale. Where many cars are to be weighed they should pass separately over the scale by gravity, being weighed while in motion.

Coaling, Ashpit, Sand and Engine Tracks.

These tracks should be located on the route leading to and from the engine house and should provide sufficient storage for the reception of engines by the hostler. They should be so arranged that water, coal and sand can be taken and ashes disposed of in convenient rotation, and that switching engines may clean fires, take coal, water and sand and pass around waiting engines.

Bad-Order Tracks.

Where cars are classified, one or more classification tracks, easy of access, should be provided for setting off cars in bad order, from which they may be readily removed to the repair tracks.

Repair Tracks.

These tracks should preferably be connected at both ends and have a maximum capacity of about 15 cars each, spaced alternately 16 feet and 24 feet center to center and be connected conveniently to bad-order tracks.

Icing Tracks.

Icing tracks should be so located that the work of shifting out, icing and classifying cars for movement can be performed in least time.

Yard.

If possible to so arrange, the main tracks of both single and double track roads should be located on the outside of yard, and the engine house, coaling station, etc., should be centrally located.

Coach Cleaning Yard.

The coach cleaning yard should be located near the terminal station. The tracks should be of sufficient length to hold full trains, with a car cleaners' repair and supply building adjacent thereto.

Inbound Freight House.

Inbound freight house should be of such width as will furnish a reasonable amount of floor space for holding freight (50 feet is a good average width). Usually not more than two tracks are needed, and the side toward the tracks should be provided with a platform and should be fitted with continuous doors to avoid the necessity for spotting cars.

Outbound Freight House.

The outbound freight house should be narrow (30 feet is a good average width) and usually not more than four to six tracks should be provided. The side toward the tracks should have a platform or continuous doors.

Where a great number of cars are required, the average trucking distance will generally be least, and trucking through cars will be avoided if the freight house is built at right angles to and at the back ends of a series of tracks built in pairs with covered platforms between.

Roadways.

Where the freight house is on one side and a wall on the other, the minimum width of roadway should be 30 feet; but where a freight house is on one side and a team track or another freight house is on the other, the minimum clear width of roadway should be 40 feet.

Transfer Station.

A transfer station should be located at a point where traffic is concentrated and where a necessity exists for consolidating freight into a less number of cars for movement to a certain destination, or for separating and reloading freight into a greater number of cars or into system cars for further movement to final delivery.

Yard at Rail and Water Terminals.

The tracks should be so arranged that as trains arrive the cars can be promptly classified and grouped for delivery without interference with other movements.

Piers.

At rail and water terminals the piers should be designed with a view to the most efficient, rapid and economical handling of the business; and with a view to its future development. Care must be taken to give due weight to the special conditions and features of location, traffic, etc., which are peculiar to each case, and which render it impossible to lay down any but the most general rules.

In every individual case the length, width, number of tracks, width of platforms, details of construction and width of waterway between adjacent piers must be adjusted to best meet conditions as to shape and area of site as well as its relation to its approach from both land and water, the character and volume of business and the manner in which it is to be handled.

Covered Lighterage Pier.

When conditions will permit, present practice will generally suggest a length of approximately 600 feet with two depressed tracks. If the business to be handled over the pier is expected to move quickly the width should be no greater than is necessary to provide temporary storage and shelter for the goods during ordinary detentions while waiting for cars or lighters, preferably about 100 feet. If the movement is expected to be slow and it is necessary to provide storage while waiting for cars or vessels, or for assorting, classifying, inspecting or sale of goods, the width should be increased, but generally not beyond a width of 125 to 160 feet. If the movement is not expected to have a special charatcer, or a mixed business is to be provided for, a compromise width of 125 feet is suggested. The space between the shed and the outer edge of the pier should be not less than two feet. The clear width of waterway between piers should be, if possible, not less than four times the width of the largest vessel to be handled.

Open Lighterage Pier.

This should, if possible, have a length of about 600 feet and the width, number of tracks and the appliances for handling traffic should be adjusted to the particular use to which the pier is to be applied. Crossovers may be necessary on long piers.

For ordinary coarse freight in bulk, such as iron ore, stone, timber and similar products, the width should be from 50 to 80 feet, and there should be four tracks, with crossovers, to facilitate the handling of cars and to avoid delay in transferring to or from vessels. If the business is light, or consists principally of heavy or costly products, such as cut stone, machinery, or miscellaneous freight not requiring shelter, a narrow pier of about 35 feet in width, with two tracks only, is recommended.

Export and Storage Pier.

This should be designed with special reference to the character of the commodities to be handled; whether quick movement is expected or the goods are to be held some time in storage for the accumulation of full cargoes, or for inspection or classification. There should be two tracks in a depressed pit on the pier level, and on long piers these should be connected by crossovers at convenient intervals to facilitate the movement of cars. On very wide piers additional tracks on the pier level are desirable under certain conditions.

Where the water front is limited or very valuable and the conditions, volume and character of business warrant, pier sheds of two or more stories, with platform or barrel elevators and bag or barrel chutes, are used. Under certain conditions additional tracks in the second story may prove more advantageous than elevators.

The length should be sufficient to properly accommodate either one or two vessels on each side at the same time or approximately 600 to 1400 feet. The width must be determined by the space available and the business to be handled. If quick moving, a width of 125 to 150 feet is recommended. If slow moving and large accumulations must be received and stored, the width may be extended, if space permits, to 300 or even 400 feet, but excessive width is not recommended on account of the consequent increase in cost of handling. The space between shed and face of pier should be not less than three nor more than six feet. The clear waterway between piers should be, if possible, not less than four times the width of the largest vessels to be handled.

Coal Pier.

This should be an open pier, and where coal is to be delivered to vessels through pockets and chutes in the ordinary way, the pier should be high enough to allow coal from drop-bottom cars to be loaded by gravity into vessels or barges. It should have three or more tracks, the outside tracks for loaded cars and the inside one on an incline to return the empty cars to the yard by gravity. The length depends upon the grade necessary to reach the desired elevation, the length of the vessel to be coaled and the number of cars it is desired to unload at one time. Adjacent piers should be sufficiently distant to accommodate the class of service, which will depend on the length of the pier and the size of the water craft to be accommodated. Where coal cars are dumped by machinery which elevates and tilts the cars a high pier is not necessary, and it may be of any convenient height.

Station Pier.

A city station pier served by car floats should be approximately 600 feet long and 125 feet wide, with a depressed driveway in the center 35 feet wide. It should be a closed pier, with a 3-foot platform outside. Adjacent parallel piers should be, if possible, 200 feet apart in the clear. Along the water street should be a bulkhead, approximately 55 feet wide, with two-story building, the upper floor being for offices, fruit auction room, etc.

Grain Elevators.

If conditions permit, grain elevators should be so located that cars may be put in at one end and taken out at the other, and without interference with other yard movements. Where this cannot be done, the tracks should be so arranged that the work of placing and removing cars may be done without serious interference with the operation of the elevator or delay to other shifting.

[3] CAR CAPACITY OF FREIGHT TRACKS.

(1) It is recommended that 42 feet per car be allowed in rating the car capacity of freight tracks.

(2) Freight car repair yards should be composed of short tracks of about fifteen cars capacity, arranged in pairs. Each pair should be spaced 16 feet center to center of tracks and the pairs should be spaced 40 feet center to center of pairs.

(3) A material supply track should be placed in the space between each pair of tracks.

(4) In computing working capacity of repair tracks 50 feet should be allowed for each car.

(5) The yard should be equipped with air and water pipes, and outlets furnished with air hose should be provided at intervals of 50 feet for testing the brakes on cars.

---

[3] Adopted, Vol. 6, 1905, pp. 579, 594; Vol. 11, Part 2, 1910, pp. 1262, 1263, 1309; Vol. 16, 1915, pp. 958, 1190.

(6) Tracks on which heavy repairs to freight cars are made should be under cover and cranes provided for heavy lifting.

[4] TEAM DELIVERY YARDS.

(1) Team delivery yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force.

(2) The tracks should be stub tracks arranged in pairs spaced 12 feet center to center, and if conditions permit the pairs should be spaced not less than 52 feet center to center of pairs, or 30 feet in clear. For convenience in handling, the tracks should not exceed 20 cars capacity each.

(3) If necessary, the yard should be provided with a crane for handling heavy freight.

(4) Ingress and egress for teams should be provided at each end of each teamway if possible.

(5) Wagon scales if installed should be at the most convenient place near the entrance to the driveway.

[5] HUMP YARDS.

(1) Hump yards should consist of receiving, classification and departure tracks in consecutive order.

(2) A hump yard is a desirable form of yard for receiving, classifying and making up trains, because a greater number of classifications can be made in less time and at less cost than through any other form of yard.

(3) Receiving tracks should be of sufficient length to hold maximum trains of the various classes handled.

(4) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to the other yards and connections.

---

[4] Adopted, Vol. 7, 1906, pp. 155, 156, 171; Vol. 11, Part 2, 1910, pp. 1263, 1309; Vol. 16, 1915, pp. 958, 1191.

[5] Adopted, Vol. 7, 1906, pp. 142, 143, 168-170, 173-179; Vol. 11, Part 2, 1910, pp. 1263, 1264, 1309; Vol. 14, 1913, pp. 936, 937, 1095-1099; Vol. 16, 1915, pp. 959, 1191.

(5) If it is possible, the grades of the receiving tracks should be such that one engine can push the maximum train over the hump.

(6) No definite recommendation can be made as to length or number of classification tracks, except that when they are to be used as departure tracks they should be long enough to hold full trains; and that when conditions permit there should be as many of them as can be used to advantage to avoid subsequent classification and consequent delay.

(7) Departure tracks should be full train length and of sufficient number to provide ample standing room for trains while being tested for air, and while waiting for engines.

A rider track should, if possible, be provided through center of classification yard, running to summit of hump, independent of other yard movements. This will avoid hazard of personal injury to car riders and reduce the number of car riders to a minimum.

(8) An air-brake testing plant should be provided in the reciving and departure yards. Pipes should be laid along the tracks, and sufficient outlets furnished (with hose) to test air brakes on all trains.

(9) To secure the greatest possible efficiency or to so construct a hump that the greatest number of cuts of cars may be classified over it, the steepest part of the grade should be reached in the least available distance after passing the summit and the grade or fall should provide sufficient momentum to carry all cars to the lower ends of classification tracks.

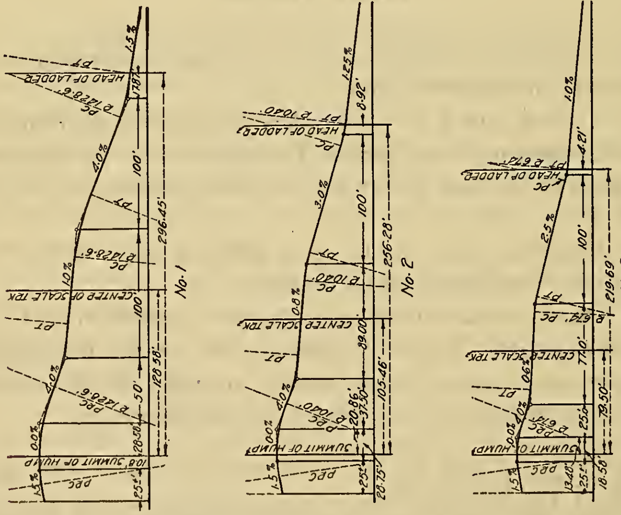


Fig. 1.

(10) *The hump profiles in Fig. 1 are recommended, as follows: No. 1, for cold climates; No. 2, for moderate climates, and No. 3 for warm climates. These are for humps with track scales and operating a mixed traffic of merchandise and empty cars.

(11) Where traffic or climatic conditions require, the summit of a hump may be made higher in the winter and restored when the increased height is not needed.

(12) When required by traffic conditions, a track scale not exceeding 60 feet in length should be located at such a distance from the summit of the hump that when cars to be weighed reach the scale they will be properly spaced from following cars and will be running slowly enough to easily secure correct weights.

(13) For average conditions it is recommended that No. 8 frog be the sharpest used in classification yards.

(14) Where tracks are set aside for holding empty cars, the grade leading to such empty track should be increased so that empty cars will move with the same velocity as loaded cars switched to adjoining tracks.

(15) The cut list system of handling cars on the hump is recommended as being efficient; it is briefly described as follows: The yard clerk makes up a list of cars to be switched and tracks they are to be placed on in receiving yard, cut No. 1 being the first car to go over the hump. It is perforated on vertical lines, so that it may be divided into multiple parts, each part being a duplicate of the other. (See Sample Cut List.)

Cut List			*Cut List*		*Cut List*		*Cut List*	
No. of Cut	No. of Track	Cars In Cu	No. of Track	Cars In Cut	No. of Track	Cars In Cut	No. of Track	Cars In Cut
1								
2								
3								
4								
5								

Where switches are thrown from a tower, one copy of the list is given to the towerman and one to the man cutting off cars on the hump.

Where switches are thrown by hand, each switchtender has a copy of the cut list, as well as the man cutting off cars on the hump.

---

*Adopted, Vol. 18, 1917, pp. 718, 1522.

[6] YARD LIGHTING.

(1) For yard lighting the use of nitrogen lights of 1500 watts capacity, equivalent to about 2200 candlepower, is recommended.

(2) For lighting hump and ladder tracks, the lamps should be spaced 140 to 150 feet apart and hung 28 feet (or more) above the tracks.

(3) For lighting body tracks, the spacing should be such that cars will be clearly visible.

[7] FREIGHT TRANSFER STATIONS.

(1) Freight transfer stations should be located at points where traffic converges or diverges, or both, and where necessity exists for its consolidation or separation.

(2) The installation should provide for the greatest possible economy of operation both as to time and cost of handling.

(3) Where fixed platforms are used, they should be covered, and it is recommended that the width under ordinary conditions be not more than 24 feet, and that the tracks on either side be built in pairs. If greater facilities are required, additional platforms 8 feet in width may be provided outside of the first two tracks and additional tracks placed outside of them. The width of these additional platforms may be 8 feet, if without roofs, or 12 feet, if covered by roofs, supported by a line of posts in the middle.

(4) Where large amounts of freight are to be transferred, the use of power-driven covered traveling platforms instead of fixed platforms is suggested.

[8] PASSENGER TERMINAL STATIONS.

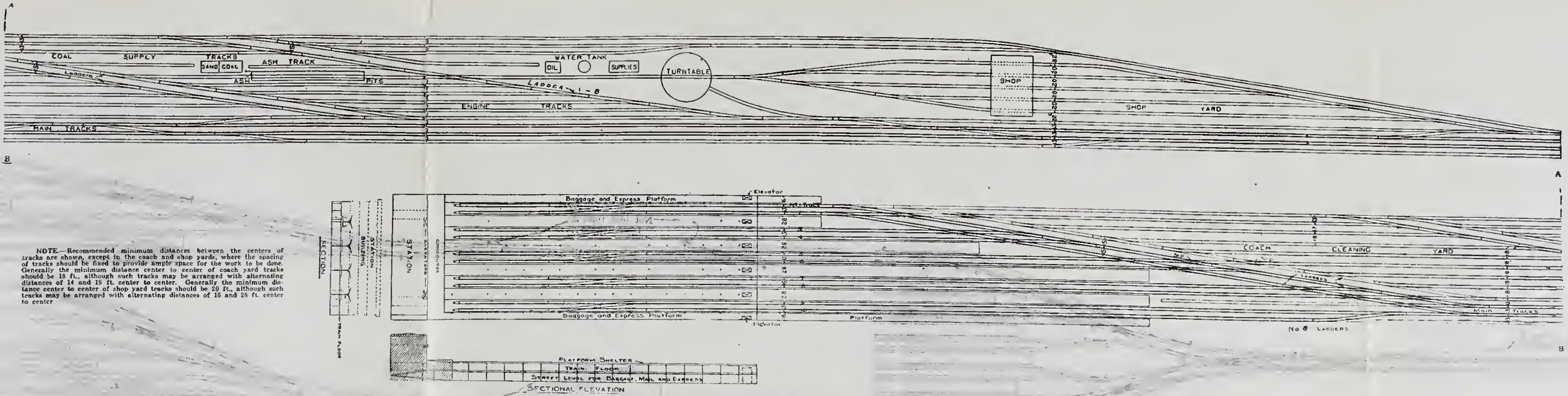
(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity which may reasonably be expected within a period of, say, twenty years. To this end the track layout must be designed to permit incoming and outgoing

---

[6] Adopted, Vol. 9, 1908, pp. 541, 584; Vol. 11, Part 2, 1910, pp. 1264, 1309; Vol. 16, 1915, pp. 959, 1191.

[7] Adopted, Vol. 7, 1906, pp. 155, 170; Vol. 11, Part 2, 1910, pp. 1264, 1265, 1309; Vol. 16, 1915, pp. 959, 1191.

[8] Adopted, Vol. 12, Part 1, 1911, pp. 240, 268; Vol. 14, 1913, pp. 924, 1090-1095; Vol. 22, 1921, pp. 898, 1077.



NOTE.—Recommended minimum distances between the centers of tracks are shown, except in the coach and shop yards, where the spacing of tracks should be fixed to provide ample space for the work to be done. Generally the minimum distance center to center of coach yard tracks should be 18 ft., although such tracks may be arranged with alternating distances of 14 and 18 ft. center to center. Generally the minimum distance center to center of shop yard tracks should be 20 ft., although such tracks may be arranged with alternating distances of 15 and 25 ft. center to center

Fig. 1—Typical Track Layout at Dead-end Passenger Terminal Station.

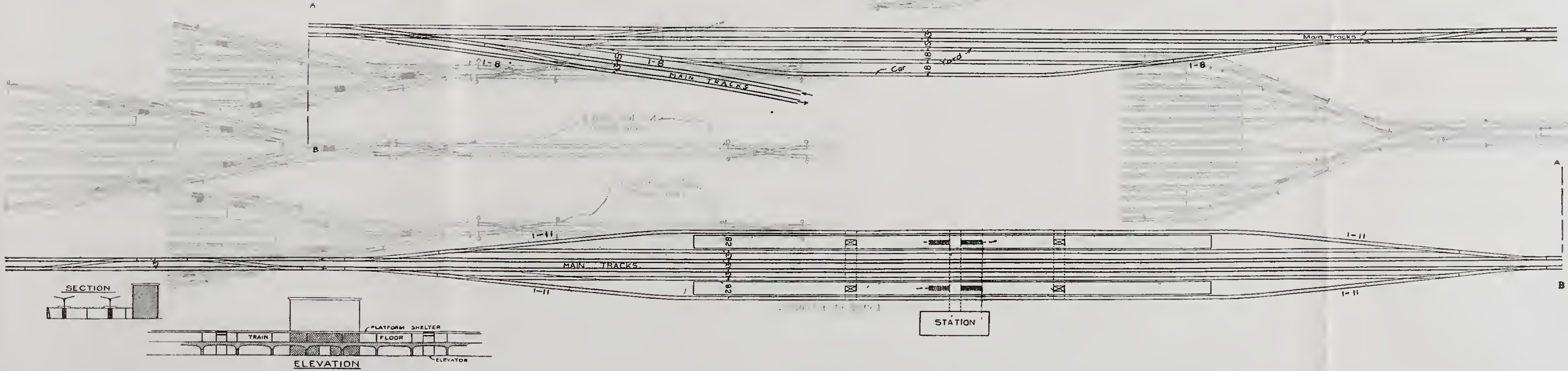
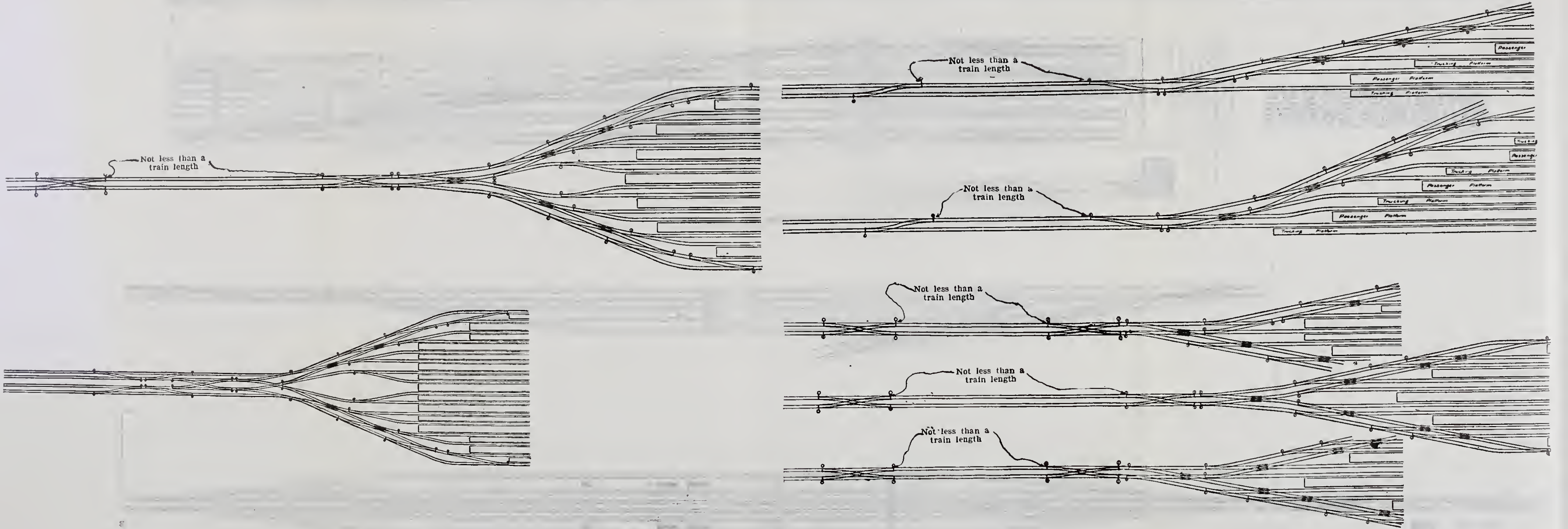


Fig. 2—Typical Track Layout at Through Passenger Terminal Station.


Not less than a train length
Not less than a train length
Passenger
Trucking Platform
Passenger Platform
Trucking Platform
Not less than a train length
Trucking
Passenger
Trucking Platform
Passenger Platform
Trucking Platform
Passenger Platform
Trucking Platform
Not less than a train length
Not less than a train length
Not less than a train length

Types of Ladders.

movements to be made at the same time without interference, as far as it is possible to arrange this.

(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit), baggage and express be received, delivered and handled below the train floor; and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers.

(3) A holding yard should be directly connected with the platform tracks to provide for a quick emptying and refilling of the latter.

(4) Where practicable, on station throat tracks the curvature through switches should not exceed that of a No. 8 slip on tangents.

[9] TYPICAL SITUATION PLANS FOR DIVISION ENGINE TERMINAL.

(1) The engine terminal should be so located as to afford easy access to both main line and yards, with the fewest possible reverse or conflicting movements.

(2) The facilities provided should be arranged to permit of the most direct and rapid handling of an engine in its terminal in the order of its needs.

[10] TRANSFER OF LADING OF BAD-ORDER CARS.

Methods of economic transfer of lading of bad-order cars in large terminals by the introduction of mechanical means or otherwise:

(1) Hand labor for transferring freight from cars in most cases is slow and expensive and without real justification.

(2) The employment of a locomotive crane is generally justified in any case where the transfer of freight from open-top cars otherwise requires the equivalent of the constant daily service of six or more men, or the intermittent service of six men where the machine may be economically employed in the interim.

(3) A study of each situation may develop extensive means of economy out of all proportion to the cost and such study is justified in each case.

---

[9] Adopted, Vol. 13, 1912, pp. 93, 947-948.

[10] Adopted, Vol. 22, 1921, pp. 891, 1077.

[11]CATECHISM OF YARD DESIGN AND OPERATION.

Principle of Yard Design.

The principle of good yard design comprises three fundamental requirements, which are:

(a) To get the train into the yard and clear the main line.

(b) To classify the cars in the yard, which includes all intrayard movement of cars and engines.

(c) To get the train out on the main track and clear the yard.

With these principles in mind, the following suggestions arise in the form of direct questions:

Questions.

1. Can you extend your yard lead or construct one adjacent to the main track of sufficient length to hold a maximum train, so that an arriving train can quickly clear the main track before entering the yard and a departing train may quickly clear the yard before going out on the main track? If trains arrive or depart at close intervals, can a second lead track be constructed? These lead tracks are sometimes called receiving or departure tracks.

2. Are your connections between
   (a) Main tracks
   (b) Lead tracks
   (c) Drill tracks (or tracks on which switch engines operate)
   (d) Yard tracks, so arranged that trains may enter and leave the yard with a minimum of interference with switching movement?

3. Are your yards so arranged and have you sufficient running tracks or thoroughfares so that you can take a transfer from one end of the yard to the other without interfering with the usual switching? Could the efficiency and capacity of the yard be increased by the enforced holding open of a track (otherwise used for holding cars) as a running track?

4. Are your crossovers so arranged as to give the least interference with switching and the greatest elasticity of movement, or can additional crossovers be put in to secure these results? Where the number of tracks in classification yard is fixed and where the number of classifications has increased, can connecting crossovers be so located between these classifica-

---

[11] Adopted, Vol. 19, 1918, pp. 316, 1121.

NOTE.—On account of the extraordinary demands upon the yards and terminals of the railway systems during the World War, the Committee made a detailed study of possible improvement of existing yards. It submitted a catechism designed to bring out hints as to the improvement in detail of existing yards and the elimination of slight defects which hinder the steady operation of yard service or cause detentions which are small in themselves but become serious in the aggregate.

The Committee suggested also, that great good could be effected on many railways by the appointment of a small committee to go over the line and make a detailed study of the operation of the larger yards for the purpose of determining instances where minor changes or additions will facilitate or cheapen operation to an appreciable extent. Such committee should be composed preferably of a representative of the engineering department who has had experience in the design of yards and has a thorough conception of yard requirements, and a practical yard man, such as a yardmaster or a yard conductor who has given evidence of a live understanding of yard operation.

tion tracks as to reduce the number of movements for the required classification?

5. If your receiving or departure tracks are too short, can you lengthen one or more tracks in each yard in order to take care of the maximum train?

6. Are your caboose tracks so located and have they such connections at each end that cabooses may be handled with the least amount of switching service?

7. Can you take the engine off your train and get it to the roundhouse, and also get it from the roundhouse to an outbound train without materially interfering with switching?

8. Can you facilitate handling road engines by providing a "tie-up," "parking" or "engine storage" track near the engine terminal?

9. Can your yard engines clean fires and take coal, sand and water without delay? Do you change switching crew where engine works, or do you send the engine to "tie-up" track for change?

10. Are the trackmen given opportunity to repair busy tracks? Are you having yard derailment or delays due to bad tracks, particularly at curves, switches and frogs?

11. Can you quicken movement of trains through the throats of the yard by putting on switch tenders at these points during the busiest part of the day?

12. Is the present assignment of tracks in the yard for the various operations the proper one?

13. Can you in any case improve the yard movement by reversing the movement of traffic?

14. Can you facilitate switching by making inexpensive changes in grade in yard at any point? If you are operating a hump, can you change the grades of the hump and facilitate switching?

15. Are you using the cut-list system in hump yards to avoid confusion in classification and to fix responsibility for damage while handling cars?

16. Can you improve switching conditions after dark by installing lights?

17. Are you handling any cars through the yard with more movements than are absolutely necessary?

18. Could you facilitate weighing and lessen interference with other switching by rearrangement of existing connections or by the addition of other connections to the scale track?

19. Are your bad order and repair tracks so located as to require the least amount of engine service?

20. Can you lessen the cost of icing cars by changing the track layout?

21. Are your car inspectors properly organized, and so located and equipped that they do not delay switching or departure of trains?

22. Can some terminal delays be avoided by the installation of compressed air lines to charge the brake equipment of trains and avoid the delay of pumping air on train after engine is coupled on?

23. Are your outgoing trains delayed "Waiting for Orders"?

24. Is your yard or road service hampered due to lack of proper telephone facilities or other means of communication?

25. Is the time of switching crews wasted by faulty handling of waybills?

[12]SPECIFICATIONS FOR THE MANUFACTURE AND INSTALLATION OF RAILWAY TRACK SCALES.*

(For Knife Edge Scales Only, Not Including Overhead Suspension Scales.)

*These specifications were prepared by a committee representing the American Railway Association, the American Railway Engineering Association, the United States Bureau of Standards, the Railroad and Warehouse Commission of Minnesota, the National Scale Men's Association and the Scale Manufacturers' Association. Acknowledgment is made of the value of similar work previously done by railways and organizations from whose specifications preferred sections and items have been selected and co-ordinated to produce a standard which should be acceptable to all interests for general use throughout the United States.

INTRODUCTION.

These specification are intended to apply to knife edge scales of the straight and torsion lever types for weighing cars in regular interchange service. They do not apply to overhead suspended scales, nor to scales now in service except that reinstallations of old scales should be governed as nearly as practicable by the provisions of the specifications relating to installation of new scales. They are intended, except in special cases, to secure reasonable uniformity in scales for similar service but without preventing improvements in types of scales or in scale parts.

Requirements not in common with other track scale specifications are the provision for two classes of scales to meet weighing conditions as determined by the volume of traffic to be weighed; and standardization of capacities and lengths as follows:

Heavy Service Scales to have sectional capacities of seventy-five and one hundred tons; and lengths of fifty, fifty-six and sixty feet.

Light Service Scales to have sectional capacities of sixty and seventy-five tons; and lengths of fifty, fifty-six and sixty feet.

Heavy Service Scales and Light Service Scales differ principally in the features which affect wear in use and not at all in strength for given capacities. It is intended that the Heavy Service Scales shall be selected for usual railroad and industry installations. The use of the Light Service Scales is intended for locations where relatively only a few cars are to be weighed.

Requests for proposals for track scales to conform to these specifications should specify the class, sectional capacity and length of scale required, together with such other information as will insure complete and uniform proposals.

---

[12] Adopted, Vol. 21, 1920, pp. 855, 1446.

SECTION I—CLASSES OF SCALES.

1. **Character of Classification:** Scales shall be divided into two classes, namely, **Heavy Service Scales** and **Light Service Scales**; and except when otherwise specifically provided these specifications are to apply to both classes of scales.

(a) **Heavy Service Scales:** Heavy Service Scales are those over which a large number of cars are to be weighed; and they shall have sectional capacities of 75 or 100 tons, except for special cases.

(b) **Light Service Scales:** Light Service Scales are those over which relatively only a few cars are to be weighed; and they shall have sectional capacities of 60 or 75 tons, except for special cases.

2. **Special Cases:** For special cases which cannot be covered in these specifications, it is recommended that the material, workmanship, etc., shall be at least equal to that required in these specifications, and that the principles herein set forth be followed in so far as they apply.

SECTION II—CAPACITY.

1. **Capacity Defined:** The capacity of a scale is equal to the weight of the heaviest car it will weigh, provided that the scale will support a train of such cars passing over the scale without stresses being developed in the members of the scale which are in excess of those hereinafter specified. The car weight for a given sectional capacity and given length of scale is shown in table for Scale Capacities and Weigh-Bridge Girders, Section XXIV.

2. **Capacity Required:** The capacity of the scale shall be sufficient to meet the requirements of the heaviest service to which it may be subjected.

3. **Sectional Capacity:** The sectional capacity of the scale is the greatest weight which, if applied on the load knife edges of each pair of main levers, will produce stresses in the scale parts not exceeding those given in the table of Working Stresses, Section IV.

SECTION III—PLANS.

1. **Plans:** The manufacturer shall furnish to the purchaser plans of design showing stresses and detailed dimensions for all scale parts, and the material of which they are to be fabricated; also assembly plans showing location of all field connections and all information necessary for the purchaser to design and construct the pit and parts not furnished by the scale manufacturer.

SECTION IV—WORKING STRESSES.

1. The following unit stresses shall not be exceeded when the scale is loaded to its capacity as defined above. These stresses include an allowance for impact caused by moving loads. The strength of each member shall be determined by its weakest cross-section.

2. **Iron and Steel, Working Stresses in Pounds Per Square Inch.**

Nature of Stress	Cast Iron	Steel Castings	Machinery Steel	Structural Steel	Steel for Pivots and Bearings	
					High Carbon	Special Alloy
Tension	1,500	8,000	8,000	10,000	24,000	30,000
Compression	8,000	10,000	8,000	10,000	24,000	30,000
Transverse Bending						
Tension	2,500	8,000	8,000	10,000	24,000	30,000
Compression	8,000	10,000	8,000	10,000	24,000	30,000
Shear	2,500	6,000	5,000	7,000	......	......
Torsion	2,500	6,000	.....	7,000	......	......

The bearing stress on steel pins shall not exceed 15,000 pounds per square inch.

3. **Knife Edge Bearing Stresses:**

(a) **Heavy Service Scales:** For Heavy Service Scales the load per linear inch of knife edge shall not exceed 5,000 pounds for high carbon steel or 6,000 pounds for special alloy steel.

(b) **Light Service Scales:** For Light Service Scales the load per linear inch of knife edge shall not exceed 6,000 pounds for high carbon steel or 7,000 pounds for special alloy steel.

4. **Concrete Bearing Stresses:** Stresses to be allowed for bearing on concrete shall not exceed 300 pounds per square inch under scale lever stands, and at all other points shall not exceed 400 pounds per square inch.

5. **Loops, Formula for Stresses:** Considering the end of the loop as a simple beam, its section at the point of maximum bending shall be determined by the formula $\frac{W}{4}\left[L - \frac{l}{2}\right]$ wherein W equals the maximum load applied to the loop, L equals the distance between the center lines of the depending sides, and l equals the distance over which the load is distributed.

6. **Projecting Pivots, Formula for Stresses:** Where practicable, the pivots shall be supported their full length by integral parts of the lever. Where impracticable to so support the pivots, the bending moments shall be determined as follows:

Let W equal the total load on both ends of pivot in pounds.
L " the moment arm in inches.
l " the length of bearing in loop, in inches.
T " distance between friction faces of loop, in inches.
B " the width of boss or sustaining member enveloping pivot, in inches.
M " bending moment in pivot, in inch pounds.

Then:

L equals ½l plus (T-B) plus ¼ in.

and:

$$M \text{ equals } \frac{WL}{2} = \frac{W}{2}\left[\tfrac{1}{2}l \text{ plus } (T-B) \text{ plus } \tfrac{1}{4} \text{ in.}\right].$$

SECTION V—LENGTH AND NUMBER OF SECTIONS.

1. **Scale Length Defined:** The length of a scale shall be considered as the effective weighing length of the live rails. In no case shall this effective weighing length be greater than the distance between the centers of end sections.

2. **Scale Lengths Standardized:** The lengths of scales, except in restricted traffic movements, or for special cases, shall be 50, 56 or 60 feet.

3. **Number of Sections:** Scales of 60 feet or less in length shall not be constructed in more than four sections.

4. **Motion Weighing:** When cars are to be weighed in motion the speed shall not exceed four miles per hour, and each car shall be entirely and alone on the scale a minimum of three seconds. This condition applies to cars normally weighed. When scales are of such a design or length as not to permit of the above condition, cars shall be spotted to secure accurate weights.

SECTION VI—SCALE LEVERS.

1. **Qualities of Castings:** The finished levers shall not be unduly warped; they shall be free from blisters, large holes or other imperfections, and shall be brought to a reasonably smooth finish.

2. **Machined Ways for Nose Irons:** Levers that are to be equipped with nose irons shall have those portions of the lever ends receiving them machined for the full distance over which the nose irons are to move.

3. **Leveling Lugs:** In scales of the straight lever type each lever shall be provided with leveling lugs for longitudinal alinement. In scales of the torsion lever type, leveling lugs shall be provided on the pipe or torsion member for transverse alinement and on the extension arm for longitudinal alinement. Each pair of lugs shall be spaced eleven (11) inches. The leveling surfaces of each pair of lugs shall be finished to a common plane which shall be parallel to the plane established by the knife edges of the end pivots.

4. **Marking of Levers:** Figures denoting the multiple of each lever shall be cast or otherwise permanently marked in plain figures thereon.

5. **Length, Allowable Variation:** All main levers shall be true to within ⅛ of an inch; and all extension levers shall be true to within ¼ of an inch of their nominal lengths between the knife edges of end pivots.

6. **Loading of Levers Other Than Main Levers:** In establishing the load for determining the stresses in the levers other than main levers, it shall be assumed that the end extension levers carry a total live and dead load corresponding to 100% of the sectional capacity; the portion of the middle extension levers carrying the load from the end section only, 100% of the sectional capacity; and the portion of the middle extension levers carrying the combined load from the end

section and inner section, 160% of the sectional capacity; the transverse extension lever, shelf lever and beam, 300% of the sectional capacity.

Section VII—Pivots and Knife Edges.

1. **Material:** The requirements for physical properties of the steel used for pivots shall be as follows:

(a) **Special Alloy Steel in the Annealed State:**

Elastic Limit	Not over 75,000 lb. per sq. in.
Tensile Strength	Not over 110,000 lb. per sq. in.
Elongation in 2 in.	Not less than 20%.
Reduction in Area	Not less than 35%.

(b) **Special Alloy Steel Hardened:**

Elastic Limit	Not less than 160,000 lb. per sq. in.
Tensile Strength	Not less than 200,000 lb. per sq. in.
Elongation in 2 in.	Not less than 5%.
Reduction in Area	Not less than 25%.
Shore Hardness	Not less than 85.

(c) **High Carbon Steel in the Annealed State:**

Elastic Limit	Not over 55,000 lb. per sq. in.
Tensile Strength	Not over 117,000 lb. per sq. in.
Elongation in 2 in.	Not less than 15%.
Reduction in Area	Not less than 25%.

(d) **High Carbon Steel Hardened:**

Elastic Limit	Not less than 135,000 lb. per sq. in.
Tensile Strength	Not less than 180,000 lb. per sq. in.
Elongation in 2 in.	Not less than 3%.
Reduction in Area	Not less than 12%.
Shore Hardness	Not less than 85.

2. **Design:** All pivots shall be designed and manufactured so that the two sides joining to form the knife edge shall make an angle that will not exceed 90 degrees; that the tolerance for offset of the knife edge of the pivot, as figured from the center line of the pivot at its base, shall be within 10% of the width of the pivot for "machined in" pivots, and 15% of the width of the pivot for "cast in" pivots.

3. **Mounting:**

(a) **Fastening:** All pivots shall be firmly fastened in position, without swedging or caulking.

(b) **Machining:** For Heavy Service Scales all pivots of the main levers shall be machined and fitted into machined ways.

(c) **Continuous Contact:** All pivots shall be mounted so as to secure equal and continuous contact of the knife edges with their respective bearings for the full length of the parts designed to be in contact; in loop bearings the knife edges shall project slightly beyond the bearings in the loops.

(d) **Position:** The pivots shall be so mounted that each knife edge in a given lever will be maintained in a horizontal plane under any load; and shall be so mounted that a plane bisecting the angle of a knife edge will be perpendicular to the horizontal plane established by the knife edges of the end pivots, and shall be so mounted that the knife edges in a given lever will be parallel to each other.

4. **Support for Projecting Pivots:** The reinforcing on the levers to support projecting pivots shall be tapered off to prevent lodgment of dirt next to the pivots and to provide proper clearances.

5. **Fulcrum Distance:** The distance between the fulcrum pivot knife edge and the load pivot knife edge in main levers of Heavy Service Scales shall be not less than eight (8) inches. For Light Service Scales it is recommended that this fulcrum distance shall be not less than six and one-half (6½) inches.

6. **Location of Main Lever Load Knife Edges:** The load knife edges of the main levers shall be so located that the center line of the live rails can be placed in the vertical plane established by the centers of those knife edges.

SECTION VIII—NOSE IRONS.

1. **Design and Fastening:** The nose irons shall be firmly fastened in proper position by means of screws or bolts of a recognized standard size and thread, or other equally effective mechanical device.

(a) **Design of Fastening:** The means for clamping the nose irons in position shall be of such design that indentations in the lever will not be made, and shall be independent of any means provided for adjustment.

(b) **Direction of Fastening:** The means for clamping nose irons in position shall force or hold them against the lever in the same direction as they would be forced by the load.

(c) **Control of Nose Iron Movement:** The movement of the nose irons shall be controlled by means of adjusting screws of recognized standard size and thread. These screws shall be made of a material which will not corrode.

2. **Marking of Position:** The position of each nose iron as determined by the factory adjustment, shall be accurately, clearly and permanently indicated by a well-defined mark on the lever and nose iron, which shall meet on a common line.

3. **Finish and Pivot Mounting:** Those surfaces of the nose irons intended to come into slidable contact with the levers shall be made true so as to secure an accurate fit of the nose irons on or in the levers. Each nose iron shall be of such design that when adjustments are made the knife edge will be held parallel to its original position.

SECTION IX—LEVER FULCRUM STANDS.

1. **Design:**

(a) **Height of Pillars and Area of Bases:** The height of the pillars and the dimensions of the bases of the stands shall be sufficient to prevent a tipping action. In stands of the two pillar type, both pillars shall be of equal height.

(b) **Pillars, Position on Bases:** The pillars or upright portions of the stands carrying the bearings shall be so placed on the bases that the centers of the bearing lines shall be over the centers of gravity of the bearing surfaces of the stands.

(c) **Anchor Bolt Holes:** Two or more anchor bolt holes, not less than two inches in diameter, shall be provided in proper places in the bases of all the stands, unless other equally effective means for anchorage is provided.

2. **Qualities of Castings:** The castings shall be free from blisters and large holes, or other imperfections, and shall be brought to a reasonably smooth finish.

3. **Bases for Lever Stands:** The bases of the stands shall be finished to within a tolerance of 1/32 of an inch, or machined when to be mounted on metal bed plates; accurate to a plane perpendicular to the axis of the upright portion of the stand, and the knife-edge bearing line shall be parallel to the surface of the base.

4. **Pillars, Finish of Tops:** The tops of the pillars for receiving the bearing steels, caps or blocks shall be finished to a tolerance of 1/32 of an inch.

5. **Tie Bars:** Tie bars for the lever frames are not required, but if used, the contiguous surfaces shall be machined.

Section X—Bearings, Bearing Blocks and Links.

1. **Material for Bearing Steels:** The character of the material for bearing steels will be found under "Knife Edges," Section VII. The bearing steels shall be equal to or greater in hardness than the knife edges which oppose them. It is found good practice to have the bearing steels not less than 95 points hardness on the Shore recording scleroscope for high carbon steel, and not less than 90 for special alloy steel.

2. **Design of Bearings:** Scales shall be so designed that when the load is applied to the live rails, the oscillation of the weigh-bridge will not displace the bearings at points of contact on the knife edges.

3. **Mounting of Bearing Steels:** All like bearing steels shall be interchangeable or mounted in interchangeable bearing steel blocks. When the steels are separable and interchangeable in the blocks they shall be fastened in position by means of set screws of a recognized standard size and thread, and of a material which will not corrode, or by other equally effective device.

4. **Finish of Bearing Steels and Bearing Blocks:** The bearing surfaces shall be brought to a smooth, true and accurate finish to provide continuity of contact with the opposing knife edges.

5. **Weigh-Bridge Bearings:** The tops of weigh-bridge bearings making contact with the weigh-bridge girders shall be finished to within 1/32 of an inch of a true plane that will bring them all to the same height when in position, and in a plane parallel to the bottom of the bases of the fulcrum stands. These tops shall be provided with

bolt holes of a sufficiently large diameter to allow for adjustment both transversely and longitudinally to secure a proper alinement of parts.

SECTION XI—LOOPS AND CONNECTIONS.

1. **Design Proportion:** In loops which form bearings for projecting pivots, the radius of the portion of the bearing making immediate contact with the knife edges and the radius of the eye of the loop shall be not less than the length of the longest side of the cross-section of the pivot to be used in the loop.

2. **Length:** All loops in like connections, except where made adjustable, shall be of the same length.

3. **Steelyard Rod:** The steelyard rod shall be equipped with a turnbuckle.

4. **Lock-Nuts:** Bolts or turnbuckles used as a part of the connections shall be provided with lock-nuts.

SECTION XII—CHECKS.

1. **Type:** All weigh-bridges shall be checked by adjustable checks of the rod or other approved type which shall be equal to the rod type in functioning.

2. **Character:** Both longitudinal and transverse checks shall be provided.

3. **Position:** The checks shall be attached as high as possible and shall be horizontal, and parallel with or perpendicular to the vertical plane through the center line of the track according to whether they are longitudinal or transverse checks.

4. **Number:** Not less than four (4) longitudinal and eight (8) transverse checks shall be provided. When the rod type is used, they shall be assumed to act in tension only.

5. **Strength:** The combined area in square inches of the check rods at either end or side shall be not less than the sectional capacity in pounds divided by 60,000 when steel check rods are used.

SECTION XIII—WEIGH-BEAM AND ACCESSORIES.

1. **Design:**

(a) **Capacity:** The maximum capacity of the beam shall be not greater than one and two-thirds (1⅔) times the sectional capacity.

(b) **Full Capacity Beam:** Except for special cases a beam of the full capacity type shall be provided.

(c) **Shoulder Stop:** A shoulder stop shall be provided on all beams to prevent the travel of the main poise back of the zero notch.

(d) **Notches:** The number of notches for the main poise shall not exceed six (6) per inch. Each notch shall be so made that when the pawl rests in it, a line projected from the center of the side of the notch nearer the zero graduation to the axis about which the pawl revolves will be perpendicular to that side of the notch.

(e) **Pawl or Latch:** The tip or point of the pawl or latch shall be of the same width as the notches of the beam, and shall be rounded off so that a small amount of dust or dirt in the bottom of the notch will not prevent the poise from assuming its correct position.

(f) **Projections and Recesses:** Poises shall be designed so as to present the least number of recesses or projections in or on which dust or dirt may accumulate.

(g) **Ball or Cone Bearings:** Ball bearings, cone bearings or other means shall be provided to secure as free a movement of the poise along the beam as possible, but without sideplay of the poise.

(h) **Registering Beam:** Scales that are to be used exclusively for spot weighing of cars or carload freight shall be equipped with a type registering, or other registering beam, of a capacity that will enable the entire load to be weighed in one draft, and without the use of additional weights of any kind, except for special weighing.

(i) **Fractional Bar Stops:** On registering beams the fractional poise shall be equipped with means to insure a positive stop at any 20-pound interval, and a stop shall be provided to prevent the movement of the fractional bar beyond its proper travel in either direction.

(j) **Operating Lever:** A substantial double or other approved type of hand grip shall be provided to facilitate the printing or registering of the weight on the ticket with the least possible disturbance of the beam.

(k) **Receptacle for Weight Ticket:** On registering beams means shall be provided to prevent the placing of the weight ticket in its receptacle in any position in which an incorrect weight can be registered.

2. **Marking:**

(a) **Intervals:** The notches and graduations on the main beam shall be made at the thousand (1000) pound intervals.

(b) **Length of Graduations:** For the main beam the zero graduation and all graduations representing multiples of 10,000 pounds shall be ¾ inches in length. All graduations having values in thousands of pounds ending in 4 and 8 shall be ½ inches in length. All other graduations shall be ¼ inches in length, or the alternative method of marking may be used in which the marks representing 5, 15, 25, etc., thousand pounds shall be not less than 1½ times the intermediate lines, and every tenth line shall be longer than every fifth line, and the lengths of the graduations other than the 5s and 10s shall be not greater than twice the distance between their centers, preferably 1½ times the distance between their centers.

(c) **Size of Figures:** For the main beam the zero graduation and every tenth graduation therefrom shall have its value in thousands of pounds (i. e., 0, 10, 20, etc.) marked by figures ⅜ inches in height, except the last graduation on beam, which shall be marked in full, for example, 200,000 pounds. All other graduations, in beams graduated by the first method, having values in thousands of pounds ending in an even figure, namely, 2, 4, 6 and 8, shall be marked by figures 3/16 inches in height. On beams graduated by the second method the 5s, 15s, etc., may or may not have the value in thousands of pounds marked, or may have a star or other device placed opposite the line. No other graduations having readings in thousands of pounds ending in an uneven figure shall be marked. All numbers shall be placed directly beneath their respective graduations and shall be within 1/16 inches to 1/8 inches of the graduation.

(d) **Fractional Beam:** For registering beams the graduations for the fractional beam shall be placed at 20-pound intervals up to and including 980 pounds, or if the fractional beam corresponds to a full 1000 pounds, the last figure shall be marked to read 999 pounds. Non-registering fractional beams shall be graduated in 50-pound intervals, except for special cases.

3. **Balance Ball:** A balance ball shall be provided and its movement shall be controlled by means of a self-contained hand operated screw or other device which will not require that the ball be rotated in making any adjustments. A means for locking the ball in position shall be provided. The balance ball shall be provided with vertical adjustment.

4. **Counterbalance Weights:** If counterbalance weights are to be used, the lower end of the hanger stem shall be threaded; a cup for the loose balancing material shall be screwed to the lower end of the stem and each additional weight shall be provided with an elongated hole in the center through which the hanger stem may pass. No slotted counterbalance weights are to be used. When no counterbalance weights are necessary on top of the counterbalance cup the cavity shall be closed by a cover, secured in a positive manner. No counterbalance weights shall be used in any place in the scale, except at the beam.

5. **Multiplication:** A pivot with a loop shall be provided at the tip of the beam. The multiplication to this pivot knife edge shall be 7000 or 10,000, which shall be plainly and permanently stamped on the beam.

6. **Identification of Parts:** Each beam shall be given a serial number which shall be stamped on the beam. The pivots, poises and fractional bar shall have stamped on them identification marks to show to which beam each belongs, and the pivots shall be so marked as to indicate their proper positions in the beam.

7. **Type Figures:** Type figures shall be made of a material sufficiently hard so that they will not easily become battered or defaced. The figures shall be plain and raised sufficiently high to insure a clear impression when the weight ticket or tape is stamped. They shall be so attached and secured in their proper places that they will not become loosened.

8. **Beam Fulcrum Stand:**

(a) **Design:** The beam shall be supported on a stand provided with compensating bearings, and shall not be suspended. The height of the pillars and the dimensions of the base of the stand shall be such as to prevent a tipping action.

(b) **Height:** The height of the stand, measured from the bottom surface of the base to the pivot bearing surface, shall not exceed 13 inches.

(c) **Finish:** The bearing surface of the base of the stand shall be finished to a plane perpendicular to the axis of the upright portion of the stand, and the knife-edge line of the bearing shall be parallel to the base. The center of the bearing line shall be vertically over the center of gravity of the bearing surface of the base.

9. **Trig Loop:**

(a) **Material:** The contact parts of the trig loop shall be made of a non-magnetic material.

(b) **Play of the Beam:** The play of the beam in the trig loop shall be not more than 2% of the distance from the trig loop to the knife edge of the fulcrum pivot.

(c) **Pointer:** The beam shall be fitted with a pointer to be used in connection with a fixed graduation or other device on the trig loop to indicate a central position in the trig loop when the beam is horizontal.

10. **Beam Support:** Cast-iron pillars or equivalent and a beam shelf shall be provided for all scales. The beam fulcrum and the trig stand shall be securely erected thereon. This shelf shall be strong and sufficiently rigid, so that it will not deflect to an extent that the action of the scale will be affected.

SECTION XIV—ANTI-FRICTION POINTS AND PLATES.

1. **Required:** Anti-friction points and plates shall be provided to limit the relative lengthwise displacement of all knife edges with respect to their bearings.

2. **Material:** The anti-friction points and plates shall be made of hardened carbon steel and the plates shall be at least as hard as the points which come in contact with them.

3. **Design:** The anti-friction points shall consist of a point or projection of small area formed on the knife edge, in the case of full length contact knife edges, or shall be formed on plates securely attached to the levers or pivots. The design of the anti-friction points shall be such that they will always make contact with their opposing plates on the line of the knife edges, within practical limits. In loop bearings the parts which come in contact with the anti-friction points shall be formed without any points or projections so that, when the loop is relatively displaced in a direction at right angles to the knife edges, the contact will continue to be made with the anti-friction points on the line of the knife edge.

4. **Clearances:** The clearances between the anti-friction plates and anti-friction points shall not exceed $\frac{1}{16}$ of an inch on the beam,

⅛ of an inch on the shelf lever, and ¼ of an inch on all other levers, and the minimum clearances shall be not less than one-half these amounts respectively.

SECTION XV—CLEARANCES.

1. The clearance around and between the fixed and live parts of the lever system of a scale shall be at least ¾ of an inch except at points where other clearances are specified.

SECTION XVI—FACTORY ADJUSTMENTS.

1. **Levers:** The design, workmanship, and factory adjustment of the levers and beam shall be such that the proper ratio of the lever arms will be maintained.

2. **Beams:** Each notch in the beam shall be adjusted to within .002 inches of the nominal distance from the zero notch.

SECTION XVII—INTERCHANGEABILITY.

1. Like parts of all like scales of the same design and manufacture shall be interchangeable unless otherwise herein specified. The scale drawings and the parts of the scale shall be marked to indicate the proper positions of the parts in the scale, so as to prevent parts not symmetrically designed being incorrectly placed when the scale is set up.

SECTION XVIII—SENSIBILITY RECIPROCAL.

1. **Definition:** The sensibility reciprocal shall be that weight required to be added to or removed from the live rails to turn the beam from a horizontal position of equilibrium in the center of the trig loop to a position of equilibrium at either limit of its travel.

2. **Value:** The sensibility reciprocal shall not exceed 50 pounds in any case.

SECTION XIX—TOLERANCE.

1. The Manufacturers' tolerance to be allowed on the first field test, after installation corrections, of all new railway track scales shall not exceed 1/20 of 1%, or 50 pounds per 100,000 pounds, for any position of the test car load on the scale. The minimum test car load to be applied shall be 30,000 pounds.

SECTION XX—LOCATION AND ELEVATION.

1. **Foundation:** Scales shall be so located that an adequate foundation, and at least fifty (50) feet of tangent track at each approach to the live rails, can be provided.

2. **Elevation:** The scale shall be raised with respect to the other tracks of the yard to such an elevation that the drainage of the surface water will be away from it. Means shall be provided to prevent surface water between the rails of the scale tracks from running into the pit.

3. **Right-Handed Beam:** Scales shall be so located that a right-handed beam can be used in all cases without the use of extension levers, exclusive of shelf lever, between transverse extension lever and beam.

SECTION XXI—FOUNDATIONS.

1. **Material:** All scale foundations shall be constructed of concrete. The qualities of the materials and the methods of mixing and placing the concrete shall be in accordance with the railroad's specifications for first-class concrete, or other first-class engineering practice may be followed.

2. **Bearing Area:** The bearing areas of the foundation footings shall be such that the bearing pressure on the soil will be uniform throughout and not exceed:

For fine sand or clay	4,000 lb. per. sq. ft.
For coarse sand and gravel or hard clay	6,000 lb. per sq. ft.
For boulders or solid rock	20,000 lb. per sq. ft.

If the soil has not a safe bearing capacity equal to that of fine sand or clay, its bearing capacity should be increased, by drainage, by adding a layer of gravel or broken stone, or by driving piles.

3. **Dimensions of Pit:** The depth of the scale pit shall be not less than seven feet (7′ 0″) from the base of the rail to the finished floor of the pit. The width of the pit between faces of side walls shall be not less than ten (10) feet for Light Service Scales, or less than ten feet six inches (10′ 6″) for Heavy Service Scales, provided that there shall be a horizontal clearance of not less than sixteen (16) inches between the faces of the side walls and the scale parts below the weigh-bridge girders and above the base of the stands. The length of the pit inside of end walls shall be not less than two (2) feet greater than the length of the scale parts.

4. **Walls of Pit:** The side and end walls shall be not less than fifteen (15) inches and preferably eighteen (18) inches thick at the top. The foundation walls of the scale house shall be not less than twelve (12) inches thick at the top and shall be formed solidly to the side walls of the scale pit.

5. **Waterproofing:** Where necessary to prevent seepage of water through foundations into the scale pit, they shall be waterproofed and drained into a waterproofed cistern located outside the scale pit and equipped with either pump, siphon or automatic "cellar drainer."

6. **Approach Walls:** Approach walls or piers of concrete shall be built to extend at least fifteen (15) feet, preferably twenty-five (25) feet, from the pit face of the end wall at the approach and back under the track, to preserve line and surface of approach tracks. They may be built in one solid mass of concrete or they may consist of two parallel walls or piers, but with either type of construction they shall have a single foundation footing. Where necessary to secure safe

bearing capacity they shall be carried to the same depth as the pit walls.

7. **Wall Batter:** All wall surfaces next to earth subject to freezing shall be constructed with a uniform batter of not less than one (1) inch to the foot, and as much more as necessary to permit the heaving of adjacent ground by frost action without disturbing the walls.

8. **Footings or Piers for Lever Stands:** The concrete footings or piers supporting the lever stands shall be not less than eighteen (18) inches thick. Their tops shall be above the floor of the pit a distance sufficient to prevent the accumulation of water under the bases of the stands, and they shall be finished to exact level and elevation to receive the lever stands directly without the use of shims or grouting. The floor of the pit may be a solid mat of concrete nearly the same thickness as that required to support the lever stands, or it may be not less than six (6) inches thick where local conditions permit. The pit floor shall in all cases be smooth and with a pitch to a common point of drainage and free from pockets in which water will stand. If the scale is of a type having main levers or parts of the platform bearings that hang below the bases of the main lever stands, the piers shall be provided with recesses of a size to give a clearance of not less than one and one-half (1½) inches and the recesses shall be formed to prevent lodgment of dirt.

9. **Anchor Bolts:** Anchor bolts shall be provided in foundations for lever stands to match the bolt holes provided for securing the stands, and they shall extend into the concrete not less than fifteen (15) inches.

10. **Anchorage for Floating Levers:** Floating levers, viz., a lever exerting an upward pull at its fulcrum, shall be anchored to the foundation to resist not less than twice the uplift produced by a train of capacity cars passing over the live rails.

11. **Deck Beam Supports:** Inverted T-rails, or bearings of steel, shall be set in the side walls of the pit with the center of bearings of the beams not less than six (6) inches from the inside face of the walls, but such bearings shall not be fastened to transverse beams.

12. **Beam Foundations:** The pillars supporting the beam shelf shall rest upon a reinforced concrete floor, steel beams or reinforced concrete beams, but the pillars and supporting beams, if used, shall be independent of the scale house floor if of timber construction. When it is necessary to install the scale beam in any building other than a regulation scale house, the pillar supports shall rest on foundations independent of the building unless the foundation of the building is free from vibrations and settlement.

Section XXII—Scale Beam House.

1. **Design:** The minimum inside width of the scale house shall be four (4) feet, and the minimum length shall be sufficient to allow the installation therein of a full-sized beam shelf and regulation beam

of proper capacity for the scale, and self-recording attachment if used. It shall be provided with a bay window, or front and end windows, located with their sills about on a level with the top of the beam shelf, and of sufficient size to give the weigher a clear and unobstructed view of the scale deck and approaching cars so that he can read the car numbers and stenciled light weights when he is weighing. The windows shall be glazed with clear glass, or clear wire glass, free from bubbles or other imperfections.

2. **Clearances:** The lateral clearance between the scale house and the center of any track shall be not less than seven feet six inches (7′ 6″), or greater if required by law or by the railroad. A clearance of not less than one (1) inch shall be provided between the inside of the scale house and beam supports and shelf.

3. **Ventilation:** Where a scale beam house is not provided with artificial heat a ventilator in the roof shall be provided.

SECTION XXIII—SETTING OF THE SCALE.

1. **Fastening of Stands:** After alining the stands, large washers shall be applied to the anchor bolts and the nuts brought down tight. The anchor bolt holes in the castings shall be filled with cement, sulphur or other suitable material.

2. **Alinement:** All levers shall be level and connections plumb throughout the scale.

SECTION XXIV—SCALE WEIGH-BRIDGES.

1. **Type of Girders:** In scales of more than two sections, weigh-bridge girders may be either of the continuous type or the non-continuous type, but non-continuous girders of such design of joints over centers of bearings as will admit of flexure vertically without derangement of sections are recommended.

2. **Steel Specifications:** Structural steel work shall conform to the specifications of the American Railway Engineering Association.

3. **Size and Strength:** The following table of Scale Capacities and Weigh-bridge Girders gives the required sizes for weigh-bridge girders. This table is based on a representative car having two axle trucks twenty-two (22) feet from center to center, truck axles five feet six inches (5′ 6″) center to center and twelve (12) feet center to center of adjacent end trucks of coupled cars.

4. **Bracing:** Each weigh-bridge span shall be designed for a lateral force of 200 pounds per linear foot plus 4% of the sectional capacity of the scale, applied at the top of the live rail and uniformly distributed.

(a) **Diagonal Bracing:** Diagonal bracing shall consist of not less than 3″ x 3″ x ⅜″ angles and not less than three (3) diagonals per span shall be used, or the equivalent of this bracing shall be employed.

(b) **Transverse Bracing:** To carry the lateral load to the knife edges of the main levers, each span shall be provided at its ends with a transverse bracing, of which the section modulus shall be not less than that determined by the formula:

$$S \text{ equals } \frac{1}{4}\,\frac{(0.04C \text{ plus } 200L)d}{10000}$$

Where:

S equals section modulus,
C equals sectional capacity in pounds,
L equals length of span in feet,
d equals distance in inches from knife edge of main lever to top of live rail, or to top flange of girder if ties are used or when pedestals are braced to resist tipping transversely to the girder.

Intermediate transverse bracing shall also be provided of a section not less than that used in the ends of the span.

(c) **Stiffeners:** Not less than one pair of stiffener angles, other than splicing angles, shall be provided over each bearing of the girders in each span of the weigh-bridge. The ends of these stiffeners shall be milled to fit the fillets of the girder flanges.

5. **Live Rail Pedestals:** The live rail shall be carried on metal pedestals, which shall be mounted on metal ties or directly on the weigh-bridge. It is recommended that, when practicable, the pedestals mounted directly on the girders be cast or fabricated in units of two, set lengthwise with the girder to prevent the tilting action of the stands, produced by the deflection of the rails under load, and that they be transversely braced. Where pedestals mounted directly on weigh-bridge girders are used they shall be so designed that they will transfer the specified lateral load to the weigh-bridge. Where cast pedestals make contact with the rail they shall have their tops machined to grade or parallel to the bottoms of the pedestals. The bottoms of the pedestals shall be machined or type metal shall be used to pour between the base and the surface on which it rests.

6. **Fabrication and Assembly:** In order to avoid distortion, each pair of weigh-bridge girders shall be fabricated complete with sway and lateral bracing in the shop under proper inspection where practicable; where this method is impracticable and where field assembly is necessary, each pair of girders shall be placed in proper alinement and the bracing then introduced and secured by bolts or rivets.

7. **Live Rails:**

(a) **Weight:** The weight and section of the live rails shall be the same as that of the dead rails. See Section XXVII.

(b) **Length:** Full length live and dead rails without splices are desirable where they can be secured, but in all cases new rails shall be used, and where splices are necessary they shall be accurately applied.

8. **Clearance Along Live Rails:** The clearance between the live rails or their pedestals and rigid deck shall be not less than one and one-half (1½) inches, and the openings shall be protected from the weather and dirt.

Scale Capacities and Weigh-Bridge Girders.

Length of Scale C. to C. End Sections,	Span C. to C. of Sections,	Main Lever Capacity,	Dead Load Main Lever Reaction,	Live Load Main Lever Reaction,	Bureau of Standards Representative Car			Dead Load Moment One Girder	Required Section Modulus	Alternative Girder Sections					
					Wheel Load,	Car Load,	Live Load Moment One Girder			Bethlehem Girder Beam		Double I-Beams		Single I-Beams	
feet	feet	pounds	pounds	pounds	pounds	tons	inch lbs. ÷ 1000	inch lbs. ÷ 1000	(f=10000)	Sizes	Sec. Mod.	Sizes	Sec. Mod.	Sizes	Sec. Mod.
60 TON SECTIONAL CAPACITY															
45	15	60,000	3,750	56,250	23,440	93.76	1,476.7	84.4	156.1	18"x92#	176.8	....	......	1-24"x80#	173.9
48	16	60.000	4,000	56,000	22,400	89.60	1,612.8	96.0	170.9	18"x92#	176.8	....	......	1-24"x80#	173.9
50	**16.67**	**60,000**	**4,170**	**55,830**	**21,810**	**87.24**	**1,704.5**	**104.3**	**180.9**	**18"x92#**	**176.8**	....	......	**1-24"x90#**	**186.5**
51	17	60,000	4,250	55,750	21,540	86.16	1,744.7	108.4	185.3	18"x92#	176.8	....	......	1-24"x90#	186.5
54	18	60,000	4,500	55,500	20,810	83.24	1,872.9	121.5	199.4	20"x112#	234.2	....	......	1-24"x100#	198.3
56	**18.67**	**60,000**	**4,670**	**55,330**	**20,390**	**81.56**	**1,960.4**	**130.8**	**209.1**	**20"x112#**	**234.2**	**2-20"x65#**	**234.0**	**1-24"x105#**	**234.3**
57	19	60,000	4,750	55,250	20,190	80.76	1,998.8	135.4	213.4	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
60	**20**	**60,000**	**5,000**	**55,000**	**19,640**	**78.56**	**2,121.1**	**150.0**	**227.1**	**20"x112#**	**234.2**	**2-20"x65#**	**234.0**	**1-24"x105#**	**234.3**
63	21	60,000	5,250	54,750	19,160	76.64	2,241.7	165.4	240.7	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
66	22	60,000	5,500	54,500	18,730	74.92	2,360.0	181.5	254.2	24"x120#	300.6	2-24"x80#	347.8	....	......
69	23	60,000	5,750	54,250	18,350	73.40	2,523.1	198.4	272.2	24"x120#	300.6	2-24"x80#	347.8	....	......
72	24	60,000	6,000	54,000	18,000	72.00	2,687.4	216.0	290.3	24"x120#	300.6	2-24"x80#	347.8	....	......

75 TON SECTIONAL CAPACITY

45	15	75,000	3,750	71,250	29,690	118.76	1,870.5	84.4	195.5	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
48	16	75,000	4,000	71,000	28,400	113.60	2,044.8	96.0	214.1	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
50	16.67	75,000	4,170	70,830	27,670	110.68	2,162.4	104.3	226.7	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
51	17	75,000	4,250	70,750	27,340	109.36	2,214.5	108.4	232.3	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
54	18	75,000	4,500	70,500	26,440	105.76	2,379.6	121.5	250.1	24"x120#	300.6	2-24"x80#	347.8	....	......
56	18.67	75,000	4,670	70,330	25,910	103.64	2,491.1	130.8	262.2	24"x120#	300.6	2-24"x80#	347.8	....	......
57	19	75,000	4,750	70,250	25,670	102.68	2,541.3	135.4	267.7	24"x120#	300.6	2-24"x80#	347.8	....	......
60	20	75,000	5,000	70,000	25,000	100.00	2,700.0	150.0	285.0	24"x120#	300.6	2-24"x80#	347.8	....	......
63	21	75,000	5,250	69,750	24,410	97.64	2,856.0	165.4	302.1	24"x120#	300.6	2-24"x80#	347.8	....	......
66	22	75,000	5,500	69,500	23,890	95.56	3,010.1	181.5	319.2	24"x140#	350.1	2-24"x80#	347.8	....	......
69	23	75,000	5,750	69,250	23,420	93.68	3,220.3	198.4	341.9	24"x140#	350.1	2-24"x80#	347.8	....	......
72	24	75,000	6,000	69,000	23,000	92.00	3,433.9	216.0	365.0	24"x140#	350.1	2-24"x80#	347.8	....	......

100 TON SECTIONAL CAPACITY

45	15	100,000	3,750	96,250	40,100	160.40	2,526.3	84.4	261.1	24"x120#	300.6	2-24"x80#	347.8	....	......
48	16	100,000	4,000	96,000	38,400	153.60	2,764.8	96.0	286.1	24"x120#	300.6	2-24"x80#	347.8	....	......
50	16.67	100,000	4,170	95,830	37,440	149.76	2,925.9	104.3	303.0	24"x120#	300.6	2-24"x80#	347.8	....	......
51	17	100,000	4,250	95,750	36,990	147.96	2,996.2	108.4	310.5	24"x120#	300.6	2-24"x80#	347.8	....	......
54	18	100,000	4,500	95,500	35,810	143.24	3,222.9	121.5	334.4	24"x140#	350.1	2-24"x80#	347.8	....	......
56	18.67	100,000	4,670	95,330	35,120	140.48	3,376.6	130.8	350.7	24"x140#	350.1	2-24"x80#	347.8	....	......
57	19	100,000	4,750	95,250	34,800	139.20	3,445.2	135.4	358.1	26"x150#	396.5	2-24"x100#	396.6	....	......
60	20	100,000	5,000	95,000	33,930	135.72	3,664.4	150.0	381.4	26"x150#	396.5	2-24"x100#	396.6	....	......
63	21	100,000	5,250	94,750	33,160	132.64	3,879.7	165.4	404.5	26"x150#	396.5	2-24"x100#	396.6	....	......
66	22	100,000	5,500	94,500	32,480	129.92	4,092.5	181.5	427.4	28"x165#	468.8	2-24"x105#	468.6	....	......
69	23	100,000	5,750	94,250	31,880	127.52	4,383.5	198.4	458.2	28"x165#	468 8	2-24"x105#	468.6	....	......
72	24	100,000	6,000	94,000	31,330	125.32	4,677.6	216.0	489.4	28"x165#	468.8	2-24"x105#	468.6	....	......

Beams in pairs to be spaced 12" C. to C.

SECTION XXV—APPROACH RAILS.

1. Positive means shall be provided to prevent creeping of the ends of approach rails, and to maintain a clearance which shall be not less than ¼ inches nor more than ¾ inches between the approach rails and the live rails unless some special means is employed to reduce impact when wheel loads pass from approach rails to live rails. The effects of rail creeping may be eliminated by the use of switch points and bent stock rails placed in the approach track in the same alinement and plane with the live rails; each switch point to be set with its squared end either next adjacent to the live rail on the scale, or with an intermediate rail between the switch point and the live rail, and securely anchored to the approach piers by means of bolts anchored therein.

SECTION XXVI—DECK.

1. **Type:** The deck or platform shall be of the fixed type, except to meet special cases.

2. **Construction:** The material for the deck shall be either reinforced concrete, wooden planking, or metal plates covered to prevent slipping, and as impervious to water as practicable.

3. **Clearances:** The clearance between the bottom of the fixed deck beams or deck supports and the I-beams forming the weighbridge shall be not less than two (2) inches.

SECTION XXVII—DEAD RAILS.

1. **Dead Rails When Required:** Scales shall be installed with dead rails or relieving apparatus, except to meet special requirements.

2. **Weight of Rails:** The weight of rails when supported on floor beams spaced two feet six inches (2′ 6″) center to center shall be not less than that given in table corresponding to the axle load; for greater spacing of the floor beams the weight of the rails shall be correspondingly increased.

Axle Load, lb.	Weight of Rail, lb.
50,000	80
55,000	85
60,000	85
65,000	90
70,000	100

3. **Transverse Beams Supporting Dead Rail:**

(a) **Structural Steel Work:** Structural steel work shall conform to the specifications of the American Railway Engineering Association.

(b) **Strength:** The following tables give the sizes and strengths required for the transverse floor beams for different axle loads and the stated assumptions:

ASSUMPTIONS: 11′-0″ c. to c. of bearings.
Dead rail offset 16″.
Floorbeams 2′-6″ c. to c.
75% of axle load carried by one beam.
Dead rails 4′-11″ c. to c.

Axle Loads	Live Load Moments in 1,000 In. Lb.	Required Section Moduli (f=10,000)	Alternative Floorbeam Sections			
			Bethlehem Beams		I-Beams	
			Sizes	Sec. Mod.	Sizes	Sec. Mod.
50,000	745.7	74.6	1-15″x54#	81.3	1-15″x60#	81.2
55,000	820.3	82.0	1-15″x54#	81.3	1-15″x60#	81.2
60,000	894.9	89.5	1-15″x73# Girder	117.8	1-15″x75#	92.2
65,000	969.5	96.9	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
70,000	1044.0	104.4	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
75,000	1118.6	111.9	1-15″x73# Girder	117.8	1-15″x90#	112.7
					or 2-15″x42#	117.8

ASSUMPTIONS: 11′-6″ c. to c. of bearings.
Dead rail offset ~~16~~″.
Floorbeams 2′-6″ c. to c.
75% of axle load carried by one beam.
Dead rails 4′-11″ c. to c.

Axle Loads	Live Load Moments in 1,000 In. Lb.	Required Section Moduli (f=10,000)	Alternative Floorbeam Sections			
			Bethlehem Beams		I-Beams	
			Sizes	Sec. Mod.	Sizes	Sec. Mod.
50,000	799.3	79.9	1-15″x54#	81.3	1-15″x60#	81.2
55,000	879.3	87.9	1-15″x64#	88.6	1-15″x70#	88.5
60,000	959.2	95.9	1-15″x73# Girder	117.8	1-15″x80#	95.8
					or 2-15″x42#	117.8
65,000	1039.1	103.9	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
70,000	1119.0	111.9	1-15″x73# Girder	117.8	1-15″x90#	112.7
					or 2-15″x42#	117.8
75,000	1199.0	119.9	1-15″x104# Girder	162.7	1-15″x100#	120.1
					or 2-15″x42#	117.8

Section XXVIII—Weather and Dirt Shields.

1. **Weather Guards:** Substantial metal guards shall be provided to cover the openings between the live rails and the deck to exclude dirt, snow and rain. They shall be so designed and fastened in place that they will be secure, but may be easily removed for inspection or repairs.

2. **Dirt Shields:** Substantial metal shields shall be provided throughout the pit, over all scale bearings and connections, applied to the deck, structural steel, or scale parts to prevent water or dirt falling into them or the accumulation of dirt or ice at points where it would interfere with the action of scale parts.

Section XXIX—Light, Drainage, Ventilation and Cleaning.

1. **Light:** Proper lighting of the scale weighing beam, scale house, scale deck and scale pit shall be provided.

2. **Drainage:** The scale pit should be kept free from water by adequate drainage.

3. **Ventilation:**

(a) **Requirements:** All scale pits shall be ventilated to meet the needs of each particular case, the object being to have the least possible amount of moist air in the pit to prevent rusting of scale points and structural steel.

(b) **Automatic Natural Ventilation:** The following arrangement is recommended for securing natural ventilation:

An opening should be made to the pit at each corner to connect with flues which terminate near the bottom of the pit, and another opening without flues extending downward should be made into the pit at its top and near its center. With such an arrangement circulation will always tend to be set up by the air whenever the pit is warmer or more moist than the outside, and when the pit is cooler or drier than the outside, circulation will tend automatically to stop. When this is done circulation will be set up only when it will tend to dry the pit.

SECTION XXX—ENTRANCE TO SCALE PIT.

1. **Location:** Entrance to scale pit for the purpose of inspection shall be through either the floor of the scale house or foundation wall, and shall be closed by a suitable door so fastened as to prevent entrance of unauthorized persons.

2. **Hatches in Deck:** If it is desired to have hatches or openings in the deck, except such as are provided for ventilation, they shall be securely fastened from the inside of the pit.

SECTION XXXI—PROTECTION FROM CORROSION.

1. **Shop Painting:** When no shop inspection is provided the steel castings and structural steel shall be given one shop coat of boiled linseed oil only. Other parts shall be painted one shop coat of red lead only. Other parts shall be painted one shop coat of red lead paint. When shop inspection is provided, all parts of the scale mechanism and structural steel shall be given one coat of red lead paint after inspection. In riveted work surfaces coming in contact shall be given one coat of red lead paint before being riveted together. All parts inaccessible after erection shall be given a second shop coat of red lead paint.

2. **Field Painting:** Scales and structural steel work shall be cleaned and painted with one coat (and preferably two coats) of paint in the field before installation.

[13] RULES FOR THE LOCATION, MAINTENANCE, OPERATION AND TESTING OF RAILWAY TRACK SCALES.

SECTION I—LOCATION.

1. **General Conditions.** The proper location of track scales depends principally on the following conditions:

---

[13] Adopted, Vol. 21, 1920, pp. 886, 1446.

(a) **The volume of traffic to be weighed in comparison with that switched over the scales and not to be weighed.** The presence of the scale in a much used track is a source of increased cost of maintenance and difficulty in inspecting and testing as well as dangerous to trainmen. In general, in yards not operated by gravity, the scale should not be located in a main drilling lead unless the number of cars to be weighed exceeds 60 per cent. of the total number of cars handled or unless the total number of movements over the main drilling lead is comparatively small.

(b) **Whether the scale is to be equipped with dead rail or relieving gear.** If practicable, scales should be located where dead rails may be used.

(c) **Whether a run around track will be installed for switching with a separate track for weighing.** Where spot weighing is done the run around track is desirable. If cars are to be weighed as classified, the weighing track need be only long enough to clear the dead rail switches. If cars are to be weighed in solid cuts, the weighing track should be long enough to hold a cut of cars to be weighed, both before and after being weighed, in order not to block operation of other tracks while weighing is being done. The weighing track may be located alongside of the drilling track, alongside of the ladder track or on an outer yard track.

(d) **Whether cars are to be weighed spotted or in motion.** If cars are to be weighed in motion the scale must be on a grade in the drilling track at the head of the classification yard.

(e) **The cost of extra switching when the scale is not located on the lead to the classification tracks.** Ordinarily the cost of the extra switching may be ignored when the integrity of the weights would be affected.

(f) **The cost of maintenance when the scale is located on the lead to the classification tracks and only a small proportion of the cars are to be weighed.**

(g) **The necessity for quick dispatch of cars that are weighed.**

2. **Position of Live and Dead Rails:** Live rails should be on the offset line and the dead rails straight unless a large portion of the cars are to be weighed. For motion weighing the offset should be divided, unless the resistance is equalized by means of a spring switch.

3. **Grade for Motion Weighing:**

(a) **Runoff Grade:** When the scale is located on the lead to the classification tracks in a hump yard it shall be at such an elevation that the cars will run by gravity as far as desired into the classification yard with a maximum speed of four (4) miles per hour over the scale.

(b) **Approach Grade:** The distance and grade from the apex of the hump to the scale should be such that the speed of free running cars will not exceed four (4) miles per hour on the scale without brake application; and such that cars can be so spaced and controlled that the weighing period of three seconds will not be reduced.

(c) **Grade of Live Rails:** Scales to be used for motion weighing should be constructed with the scale rails on a gradient not greater than one per cent. The weighing mechanism must in all cases be installed on a level plane, with supports introduced to fix weighing rails on the desired gradient.

(d) **Grade for Weighing Cuts of Cars:** The grade of the track for at least one car length in each direction from the scale should be the same as the grade over the scale. Where it is the practice for one car rider to take several cars together into a classification track, the same grade as on the scale should be maintained for at least one hundred (100) and preferably two hundred (200) feet beyond the scale so that cars may be stopped easily by the car rider and so that the following cars will not cause excessive impact when striking the cars ahead. This should occur not less than one car length from the scale.

4. **Runoff Grade for Spot Weighing:** When a scale is installed not in connection with a hump, it is desirable that it be high enough to permit cars to run away from the scale by gravity after being weighed.

SECTION II—MAINTENANCE AND OPERATION.

1. **Numbering Scales:** All track scales should be numbered and referred to by number and location.

2. **Scale Shop:** Extensive repairs to scales, such as the renewal or the sharpening of pivots, should be made in a properly appointed shop.

3. **Cleaning:** When scales are in service regularly, scale parts, substructure and foundations should be cleaned at least twice a month, and when exposed to the elements, or otherwise so located that they are liable to become clogged with ice or dirt, should be cleaned oftener.

4. **Rust Preventive for Pivot and Bearing Steels:** The best rust preventive obtainable should be applied to pivot and bearing steels, but it should be so applied as not to interfere with the proper working of the scale.

5. **Removal of Ice:** If ice obstructs the action of the scale, salt should not be used to melt it; artificial heat should be used.

6. **Standing of Equipment Prohibited:** Equipment should not be allowed to stand on the scale, except when being weighed.

7. **Restrictions to Use of Live Rails:** Engines or similar heavy equipment should not be passed over the live rails, except on authority of the department having supervision over the installation and maintenance of scales. The unnecessary passing of cars over the live rails should be prohibited. Weighed cars which have passed beyond the dead rail switch must not be returned over the live rails. The dead rail switches should be set for the dead rail track except when cars are being weighed.

8. **Cars Restricted to Live Rails or Dead Rails Only:** Cars on the live rails must not be moved by cars or engines on the dead rails

or vice versa. Cars must not be moved over the scale with one truck on the live rails and another truck on the dead rails.

9. **Use of Sand and Injector by Enginemen Prohibited:** Enginemen must not apply sand or use the injector when on the scale. The slipping of engine drivers on either live or dead rails is injurious to the structure and should be avoided.

10. **Weigh-beam:** The weigh-beam should be balanced before the scale is used. When not in use it should be secured by the beam catch and with the poise set at the highest graduation.

11. **Stopping Cars on Scales:** Cars should not be stopped on the scale by impact, by the sudden application of brakes or by throwing obstructions under the wheels. When pushing off the scale cars which have been stopped for weighing or otherwise, impact must not occur at a speed greater than two miles per hour. When necessary for any reason to run cars over the live rails, the speed must not exceed four (4) miles per hour.

12. **Automatic Weighing and Recording:** Where automatic weighing and recording devices are used it is absolutely necessary that both the scale and the automatic devices be in first-class condition, with properly maintained approach track, and cars must be run at a slow rate of speed with particular attention to steadiness of motion which is essential to obtaining best results.

13. **Locking Scale Houses:** Scale houses and beam boxes must be kept locked when not being used.

14. **Inspection by Weighmaster:** The weighmaster should familiarize himself with the construction of the scale and make inspections at such intervals as are necessary to determine whether or not the scale is in proper working condition. The weighmaster and anyone appointed to inspect and clean the scale should be properly instructed, and it is desirable that they be present with the scale inspector when the scale is tested.

15. **Painting:** The scale mechanism and structural steel should be painted often enough to prevent corrosion.

SECTION III—TESTING.

1. **Tests with Single Test Cars:** Track scales in regular car weighing service should be tested at least every three months with a test car weighing not less than thirty thousand (30,000) pounds.

2. **Graduated Tests:** Scales when installed and periodically thereafter should be given a graduated test with two or more test loads up to the weight of the heaviest cars normally weighed. The frequency with which such graduated tests should be made depends on the design, capacity and method of installation of the scale used, the wear of scale pivots, and the amount of weighing performed.

3. **Weekly Tests:** A test should be made each week by weighing a heavily loaded freight car with as short a wheel base as is obtainable on each end and center of scale. When the scale is equipped with an

automatic weighing attachment the car should, in addition to the above, be weighed spotted on the trip end of the scale and in motion with the automatic attachment connected. A report of these tests should be sent to the officer in charge of scales and weighing.

4. **Daily Tests:** In addition to the above, a daily test should also be made on each scale equipped with an automatic attachment, by weighing a car spotted on the trip end of the scale with the beam, also in motion with the automatic attachment connected. A book record of this and other tests should be kept by the weighmaster.

5. **Adjustment:** Track scales should be kept in the closest possible adjustment, and a scale should be considered inaccurate when it cannot be adjusted, and such adjustment maintained to within two (2) pounds to one thousand (1000) pounds, in excess or deficiency, when distributed test is made with two or more test loads. When only concentrated sectional tests are made, the maximum error for any position of the test load should not exceed three (3) pounds to each one thousand (1000) pounds of test load used.

The sensibility reciprocal of a track scale should never be more than one hundred (100) pounds.

NOTE:—No uniform plan can be outlined for adjusting track scales of the different types manufactured, but as an illustration of the method followed, a system is given which is in a general way applicable to the more common types of lever systems generally used.

SECTION IV—EQUIPMENT FOR TESTING.

1. **Standard of Mass:** The standards of mass for testing scales should be derived from primary weights, verified by the U. S. Bureau of Standards, Washington, D. C., to within what is known as their "Class B Tolerance." Such weights can be obtained either direct or through scale manufacturers. The fifty (50) pound secondary or working cast-iron weights, which are transported from place to place and used directly in testing scales, should be rectangular, and of such design as to facilitate stacking; they should be free from pockets, blow holes, etc., which are liable to catch and hold foreign matter. No adjusting cavity or cavities in the bottom of the weights should be permitted.

These weights should be properly painted, surfaces maintained in good condition, and be tested and adjusted in comparison with master-weights, which have been verified to within "Class C Tolerance." The working weights shall be adjusted to within twenty-five (25) grains and maintained to within one hundred (100) grains of their true values.

NOTE:—The standards for testing scales in the Republic of Mexico must be in accordance with the metric system standards and will be verified by a Federal scale inspector in accordance with the Federal laws.

2. **Even Arm Balance and Master Scales:** It is desirable for

verifying or scaling test weights and test cars to have, in addition to standards of mass prescribed above:

(a) An accurate even arm balance of one hundred (100) pounds capacity in each pan, sensitive when loaded to two grains.

(b) A master scale.

Section V—General Specifications for Master Scales.

1. The master scale shall be of sufficient length and capacity for sealing test-weight cars and should be installed under cover, at a location as free from vibrations, resulting from machinery, train or other causes, as possible. The use of it should be limited to the verification of test cars or for other special weighing where extreme accuracy is required. It should not be used for general weighing purposes, nor be run over with cars or material not to be weighed. A scale of the two-section track scale type is recommended.

2. The length of weighing rail should be sufficient to weigh in one operation test cars in use or contemplated. Scale with weighing rail not less than ten (10) feet in length is recommended. The approach rails to master scale should be on a tangent for a distance slightly in excess of the longest wheel base cars to be weighed on the scale. To facilitate test with equipment such as is used by the Bureau of Standards, the tangent on at least one approach should be not less than fifty (50) feet.

3. The capacity of scale should be determined by the heaviest load to be weighed upon it when concentrated on a five (5) foot wheel base, without stresses being developed in the parts of the scale in excess of those specified in Section IV of the Specifications for the Manufacture and Installation of Railway Track Scales, June 6, 1919. A scale of not less than one hundred thousand (100,000) pounds is recommended.

4. The scale should be equipped with a single beam with a capacity not to exceed one thousand (1000) pounds, the value of minimum graduations not to exceed five (5) pounds. Multiplication at butt of beam 100 to 1, multiplication of the beam 10 to 1, and ratio of counterweights 1000 to 1 are recommended.

5. The angular movement of the beam should be limited by the trig-loop, and should be two (2) per cent. of the distance between the trig-loop and the fulcrum knife-edge.

6. The sensibility reciprocal should correspond to fifty (50) per cent. of the angular movement of the beam. The sensibility reciprocal should never be greater than five (5) pounds.

7. Master scale, when installed, and at least once each year thereafter, should be given a graduated test up to the weight of the heaviest loads to be weighed upon it (preferably to full capacity).

Tolerance on counter poise weights is as follows:

Weight Pounds.	*Tolerance Grains.*	*Weight Pounds.*	*Tolerance Grains.*
50	10	2.	1.5
25	6	1.	1.0
20	6	0.8	1.0
15	4	0.5	0.5
10	4	0.4	0.5
8	3	0.3	0.5
5	3	0.2	0.5
4	2	0.1	0.3
3	2		

Master scales should be capable of being adjusted and maintained to within the tolerances for adjustment and maintenance, respectively, as given in the following table:

Test Load.	*Tolerance in Pounds.*	
Pounds.	*For Adjustment.*	*For Maintenance.*
20,000	3.00	6.00
30,000	3.68	7.36
40,000	4.24	8.48
50,000	4.75	9.49
60,000	5.20	10.40
70,000	5.62	11.22
80,000	6.00	12.00
90,000	6.37	12.74

8. To facilitate calibration of master scales, the use of special weights heavier than the usual fifty (50) pound commercial test weights are desirable.

Tolerance of Weights weighing respectively 2500, 5000 and 10,000 pounds is as follows:

Weight.	*Tolerance.*	
Pounds.	*Grains.*	*Pounds.*
2,500	440	.063
5,000	650	.093
10,000	975	.139

9. Master scales should be kept clean, dry and free from rust, and it is recommended that this work be looked after only by an experienced scale man.

NOTE.—The following sections and paragraphs in the Specifications for the Manufacture and Installation of Railway Track Scales, dated June 6, 1919, apply also to master scales as well as to track scales.

Section III, and IV, Sec. V, paragraph 1; Sec. VI, paragraphs 1 to 5 inclusive; Secs. VII, VIII, IX, X, and XI, Sec. XII, paragraphs 1 to 3 inclusive; Sec. XIII, paragraphs 1c, 3, 4, 6, 8 (a), 8 (c), 9, and 10; Secs. XIV, XV, XVI, and XVII; Sec. XVIII, paragraph 1; Sec. XXI, paragraphs 1, 2, 4, 5, 7, 8, 9, 12; Secs. XXIII and XXVIII; Sec. XXIX, paragraphs 1 to 3 (a) inclusive, and Sec. XXXI.

It should not be overlooked that extraordinary care is necessary in the design and installation of master scales, and preparation of foundation to insure stability, in order that scales will meet the sensibility and tolerance requirements specified above, and consistently hold their adjustment as determined by repeated weighings.

SECTION VI—SCALE TEST CARS.

1. For general track-scale testing test cars should weigh not less than a total of thirty thousand (30,000) pounds, nor more than eighty thousand (80,000) pounds. For making graduated tests and to simplify computations, cars weighing eighty thousand (80,000) pounds and forty thousand (40,000) pounds, respectively, are suggested. The maximum weight of 80,000 pounds is suggested principally in order to reduce the number of restricted movements due to weight limits on scales, bridges, etc.

2. Scale test cars of proper design should have the following characteristics:

(a) All-metal construction.

(b) Length of wheel-base not to exceed seven (7) feet.

(c) Load distributed uniformly on wheels.

(d) No unnecessary ledges or projections likely to catch and hold dirt.

(e) No unnecessary parts.

(f) Strength and durability, so that frequent repairs will not be necessary.

(g) Surface area reduced as much as possible, to limit wind pressure.

(h) Accessibility of all parts for inspection.

(i) Roller or ball bearings reduce rolling resistance, thereby providing for ease of movement by scale inspector. They do not require sponging and repacking of journal boxes, which materially changes weight of test car between periods of verification and for these reasons are preferable to journal bearings.

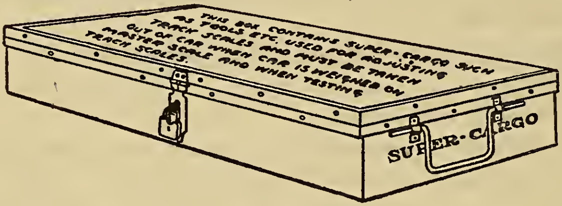
3. Test cars may be of the self-contained type, having a body of solid castings with space provided for a small amount of test weights, or of the compartment type, having a body of structural and plate steel with space for test weights equal in weight to that of the car. The car of the self-contained type is preferable.

4. When supercargo (consisting of tools, overclothes, etc.) is carried in test car, it should be removed when the weight of car is being verified on master scale, also when testing track scales. To facilitate handling of supercargo, it should be contained in a removable steel box, properly stenciled to show that it is not a part of the test load. (See cut below.) There should be stenciled on the outside of each of the doors of the compartment in which this box is carried the following note:

"This box contains supercargo, such as tools, etc., used for adjusting track scales, and must be taken out of car when car is weighed on master scale and when testing track scales."

5. Scale test cars should be moved on the rear end of trains, just ahead of the caboose.

6. Scale test cars should not be kept on trains in yards while the latter are being switched, but should be so placed that rough handling will be avoided. In no case should these cars be subjected to impact at a speed greater than two (2) miles per hour.


THIS BOX CONTAINS SUPER-CARGO SUCH
AS TOOLS ETC. USED FOR ADJUSTING
TRACK SCALES AND MUST BE TAKEN
OUT OF CAR WHEN CAR IS WEIGHED ON
MASTER SCALE AND WHEN TESTING
TRACK SCALES.
SUPER-CARGO

7. All excess weight, resulting from the accumulations of snow and ice, should be removed from scale test cars before they are placed on scales for the purpose of testing. To remove this, an engine with steam-hose connections may be used to thaw it, or hydro-carbon, where available, may be employed if used with care.

8. Oiling and repacking of test cars should be looked after while test car is at master scale for verification.

9. Scale test cars should be verified on master scale at least every three (3) months, or after each general test trip.

10. In order to maintain the verified weight of the scale test cars at all times, no repairs of any nature should be made while in transit or boxes sponged without notifying the scale inspector in charge of the car, in order that he may be present to determine and arrange to take care of any differences between the weight of parts applied and those removed. To insure compliance with this rule, there should be located in a conspicuous place, so that it can be read from either side of the car, a badge-plate, with some such notice as: "Do not oil or repack boxes or make repairs to this car unless directed by scale inspector."

11. In case a scale test car is damaged so as to require extensive or heavy repairs, it should be returned to the master scale for verification after the repairs have been completed.

COMMITTEE XV.

IRON AND STEEL STRUCTURES.

[1]INSPECTION OF BRIDGES AND RECORDS OF INSPECTION.

(1) Inspection by the regular section forces, daily, or as often as they inspect the track under their supervision. The object of this inspection is to discover any damage to the structure from fire, flood, derailments or other accidents from traffic, or any displacement in the structure in whole or in part. This inspection, due to the lack of skill on the part of the section forces, must necessarily be superficial, and will rarely, if ever, do more than call attention to unsafe conditions arising from causes other than those of natural depreciation. No reports of such inspections need be made unless adverse conditions are discovered.

(2) At periodic intervals of from one to six months there should be inspections by bridge foremen and others experienced in bridge repairs. These inspections should be more thorough than those of the section forces, and are intended to discover all the defects, arising from traffic, to which the bridge is subjected, and those due to natural depreciation or other causes. Reports of such inspections should be made to the one next in authority; preferably to the one most directly or primarily responsible for the safety of the structures.

(3) Annual or semi-annual inspections are to be made by men experienced in the design and maintenance of bridges; preferably by those who are primarily responsible for their safe maintenance. The reports of these inspections should be filed, and in connection with an examination of office data will determine the safety of the structures, and be the basis for decisions as to repairs, reinforcements or renewals.

[2]INSTRUCTIONS FOR THE MILL INSPECTION OF STRUCTURAL STEEL.

(1) Study the contract and specifications and secure such information concerning the proposed structure as will permit a full understanding of the use to be made of the various items of the order.

(2) Secure copies of the mill orders, shipping directions and other information concerning the material to be inspected.

(3) Attend promptly when notified of the rolling of material and so conduct the inspection and tests as not to interfere unnecessarily with the operations of the mill.

---

[1] Adopted, Vol. 11, Part 1, 1910, pp. 126, 127, 166.
[2] Adopted, Vol. 14, 1913, pp. 86, 87, 1049-1050.

(4) Have the test specimens prepared and properly stamped with the melt numbers by the manufacturer. Observe the selection and stamping of specimens and verify the melt numbers when practicable.

(5) Attend and supervise the making of tensile, bending and drifting tests. Make sure that the testing machines are properly handled and that the specified speed of pulling is not exceeded. Note the behavior of the metal and check and record the results of the tests.

(6) Select the bars or other members for full-size tests as specified. Supervise such tests and check and record their results.

(7) Secure from the manufacturer records of the chemical analyses of the melts and accept only those in which the specified contents of impurities are not exceeded.

(8) Secure pieces of the test ingots and test specimens and have check analyses made outside of the manufacturers' laboratory when the analyses furnished by the manufacturer are erratic or for any other reason appear to be incorrect.

(9) Examine each piece of finished material for surface defects before shipment, requiring the material to be handled in a manner that will permit the examination to be thorough and complete. This inspection should detect evidence of excessive gagging or other injury due to cold straightening.

(10) Report promptly the shipment of any material from the mill, whose surface inspection has been waived. Such material should be examined by the shop inspector.

(11) Verify the section of all material by measurements and by weight.

(12) Study the operations of the plant and become familiar with the various processes of manufacture.

Cultivate the acquaintance of the mill employés and become familiar with their work so as to have direct knowledge of the mill practice and determine as well as the circumstances permit the correctness of the mill practice in so far as it is covered by the specifications.

(13) Record all tests and analyses on the forms provided.

(14) Keep informed as to the progress of the work in the shop and endeavor to secure the shipment of material at such times and in such order as to avoid delay in the fabrication.

(15) Secure copies of the shipping lists and compare them with the orders and make regular statements of the material that has been rolled and shipped.

(16) Make reports weekly or as may be directed, submitting complete records of tests, analyses and shipments and such other information as may be required.

[3] INSTRUCTIONS FOR THE INSPECTION OF THE FABRICATION OF STEEL BRIDGES.

(1) Acquire a full knowledge of the conditions of the contract, such as the time of delivery, the railway company's actual need of the work, the desired order of shipment, and any special features in connection with the delivery, such as the position of the girders or truss members on cars at the bridge site.

(2) Study in advance the plans and specifications and see that all provisions thereof are complied with. These instructions are not to be construed as altering the specifications in any way.

(3) Endeavor to maintain pleasant relations with foremen and workmen; and by fairness, decisiveness and good sense, interest them in the successful completion of the work.

(4) Attend constantly to the work, making inspection during the progress of the work in the shop, striving to keep up with the output in order that errors may be corrected before the work leaves the shop.

Conduct the inspection so as not to interfere unnecessarily with the routine operations of the shop.

(5) When unusual circumstances require an explanation of the plans or some variation from the specified procedure, take the necessary action promptly.

(6) Study the field connections, paying particular attention to clearances and making notations on the drawings so that they may be checked rapidly.

(7) Check all bevels and field rivet holes.

(8) Give careful attention to the quality of the workmanship, the condition of the plain material, accuracy of punching, care in assembling, alinement of rivets, tightness of rivets, accuracy of finishing of machined joints, painting and general finish.

(9) Make sure that reamed holes are truly cylindrical and that drillings are not allowed to remain between assembled parts.

(10) Watch for bends, kinks and twists in the finished members and make certain that when leaving the shop members are in proper condition for erection.

---

[3] Adopted, Vol. 14, 1913, pp. 87-89, 1050-1053; Vol. 15, 1914, pp. 410, 411, 1058.

(11) Make sure that the webs of girders do not project beyond the flange angles and that the depth of web below the flange angles complies with the specification.

(12) Allow only the material rolled and accepted for the work to be used therein.

(13) Have the fabricated material shipped in the correct order for erection and in accordance with instructions, as far as practicable.

(14) Measure the width of each column and the lengths of all girders between columns when they are to be placed consecutively in a long row so as to insure that the columns and girders will not "build out" in erection so as to exceed the calculated length.

(15) Check "rights" and "lefts" and make sure that the proper number of each is shipped.

(16) Check base plates of girders before riveting and make sure that the bevel is not reversed.

(17) Check the space provided for driving field rivets, allowing sufficient space for the pneumatic riveter.

(18) Examine field connections after riveting to insure proper fitting and ease of erection.

(19) Make sure that shop splices are properly fitted and that matched and milled surfaces to transmit bearing are in close contact during riveting as specified.

(20) Examine and measure bored pinholes carefully to insure proper position, dimension, spacing and smoothness of finish.

(21) Measure the spacing center to center of the end connections for sections of I-beam floors or any similar construction in which the calculated spacing is liable to be exceeded because of the tendency of such work to "grow" as it is assembled.

(22) Make sure that stringers connecting to floor beams beneath the flange have sufficient clearance to care for their possible over-run in depth.

(23) Have the assembling of trusses and girder spans required by the specifications carefully done and in any case insure the accuracy of field connections. If a large number of duplicate parts are to be made, the number of parts to be assembled should be governed by the workmanship. If errors are found, a sufficient number of parts should be assembled to make it reasonably certain that such errors have been eliminated.

(24) Secure match-marking diagrams for work which has been assembled and reamed and make sure that the match marks are plainly visible.

(25) Have proper camber blocking used in assembling trusses and secure the desired camber before the reaming is done.

(26) Require that all treads and supports for the drums of draw spans be carefully leveled with an instrument.

(27) Study carefully the machine details and discriminate between those dimensions which must be exact and those in which slight variations are permissible.

Determine in advance the desired accuracy of fits for bolts or keys and similar parts and make sure that such accuracy is attained.

(28) Examine castings carefully for blowholes and other imperfections and discriminate between such defects as are unimportant and those which render the castings unfit for use.

(29) Make sure that bushings, collars and similar parts are held securely in place.

(30) Make sure that all drum wheels, expansion rollers, turntable rollers and similar parts are exact in size, so as to carry equally the loads which may be placed upon them.

(31) Ascertain in advance that the paint provided complies with specifications. Watch carefully the painting directions and make sure that paint is properly applied and only where intended.

(32) Verify all shop marks and make sure that they are legible as well as correct.

(33) Have important members so loaded as to be headed in the right direction upon arrival at the site of the work.

(34) Try a few countersunk head bolts in the holes where they are to be used to insure a proper fit.

(35) Make sure that small pieces are bolted in place for shipment as shown on the plans and that other small parts are properly boxed or otherwise secured against loss.

(36) Make sure that rivets, tie rods, anchor bolts and miscellaneous parts are shipped so as to avoid delay in erection.

(37) Examine the field rivets to insure that they are free from fins or other defects.

(38) Exercise special care in the examination of all movable structures and particularly their moving parts.

(39) Make reports weekly or as directed, exhibiting carefully and concisely the actual conditions.

(40) Observe carefully and report such unusual difficulties as may be encountered and the means adopted in overcoming them and endeavor

by a study of the details or other means to make recommendations which will prevent their recurrence in future work.

(41) Check every finished member against the drawings for its general dimensions and for the section of each piece of material forming a component part of the member.

(42) Attend the weighing of material whenever practicable, especially that purchased on weight basis. Check the accuracy of the scales with test weights or by other sufficient means.

[4] INSTRUCTIONS FOR THE INSPECTION OF BRIDGE ERECTION.

(1) Study and observe the plans and specifications for steel construction. Study the masonry plans and check the masonry as built with the steel plans.

(2) Familiarize yourself with the local conditions affecting erection. Make the acquaintance of the principal men engaged upon the work and of local residents whose interests may be affected thereby.

(3) Obtain and study carefully the employees' timetable and be well posted concerning the time and relative importance of regular and extra trains. Acquaint yourself with all special traffic arrangements made because of the work in hand.

(4) Secure full information concerning the condition of the work in the bridge shop and the probable dates of shipment.

(5) Obtain reports of any uncompleted or erroneous work that must be attended to after arrival of the material in the field.

(6) Study the erection program in order to avoid delays and be able to recommend some other procedure in an emergency.

(7) Endeavor to have full preparations made before disturbing the track so that the erection may proceed rapidly and the period of such disturbance be made a minimum.

(8) Keep a record of the arrival of all materials. The contractor's record should be sufficient if available. Strive to anticipate any shortage of material and use all available facilities to hasten delivery of the needed parts.

(9) Study the progress of the work and determine whether it is likely to be completed in the time allotted. If not, endeavor to secure such additions to the force and equipment as will insure such completion,

---

[4] Adopted, Vol. 14, 1913, pp. 90, 91, 1053-1057.

(10) Make a daily record of the force employed and the distribution of labor, in a way that will assist in following paragraphs 9 and 23.

(11) Exercise a constant supervision of any temporary structure or falsework and make soundings if necessary with the purpose of discovering any evidence of failure or lack of safety and having it corrected before damage is done. Examine erection equipment with a view to its safety and adequacy.

(12) Be constantly on hand when work is in progress and note any damage to the metal, failure to conform to the specifications, or any especial difficulty in assembling.

(13) Make sure that each member of the structure is placed in its proper position. If match marks are used, examine them with care.

Endeavor to have the several members assembled in such order that no unsatisfactory makeshifts need be resorted to in getting some minor member in place.

(14) Prevent any abuse or rough usage of the material. Bending, straining and heavy pounding with sledges are included in such abuse.

(15) Watch carefully the use of fillers, washers and threaded members to see that they are neither omitted nor misused.

(16) Make certain that all parts of the structure are properly aligned and that the required camber exists before riveting. It is possible for a structure to be badly distorted, although the rivet holes are well filled with bolts.

(17) Watch the heating of rivets to prevent underheating or overheating and to make sure that scale is removed.

Examine and test carefully all field-driven rivets and have any that are loose or imperfect replaced.

Have cut out and replaced all rivets, whether shop-driven or field-driven, that may be loosened during erection and riveting.

Prevent injury to metal while removing rivets.

(18) Present to the contractor at once for his attention any violation of the specifications or contract, and secure a correction or refer the matter to the proper authorities as soon as possible.

(19) Keep informed concerning the use of Company material and work trains and assist in procuring such material and trains when needed, and preserve a record thereof.

(20) Secure a match-marking diagram of any old structure to be removed which it is desired to re-erect and see that each part of such structure is properly marked in accordance therewith. Make a record of the manner of cutting the old structure apart and report any damage to

the members of the old structure. Indicate by sketches or otherwise such repairs or replacements as will be found necessary in re-erection.

(21) Secure photographic records of progress and the important features of the work wherever practicable.

(22) Make a record of all flagging of trains, whether performed for the benefit of the contractor or otherwise, delay to trains, personal injuries and accidents of every kind.

(23) Make reports as directed, showing the progress of the work, the size of the force and the equipment in use.

Make a final report showing the cost of labor of erection per ton of material erected, the cost of labor per rivet in riveting, the cost of correcting errors in design and fabrication and commenting on the design and details; and give such other information as may be useful in planning similar work.

[5] COLUMN TESTS.

The conclusions that seem warranted from the tests so far made in the proposed series are:

(1) Columns in which batten plates are substituted for lacing bars will not develop the full strength of the section and should not be used.

(2) The specimen tensile tests on which material is ordered and accepted afford no proper criterion for the strength of a column.

(3) A column designed so that it fails as a whole and not by reason of local weakness will have an ultimate strength of which the compressive yield point of the material of which it is made up is an index, since the higher this yield point is, the stronger will be the column.

[6] COLUMN FORMULA.

The following formula is recommended for use with ordinary structural steel for which the basic unit tensile stress is 16000, and for ratios of $\frac{l}{r}$ not greater than 200:

$$p = 15000 - 50\frac{l}{r}, \text{ but not to exceed } 12500.$$

---

[5] Adopted, Vol. 19, 1918, pp. 793, 1190.

[6] Adopted, Vol. 21, 1920, pp. 489, 1398.

REQUIREMENTS FOR THE PROTECTION OF TRAFFIC AT MOVABLE BRIDGES.

The protective appliances at drawbridges consist in devices for insuring that the bridge is in proper position, and the track in condition for the passage of trains over draw, or for reduction to a minimum of the damage in case of trains not stopping when track is not in condition for passage of same over draw; also the usual devices for protection against damage in case of derailment.

The protective devices may be classified under the headings:

(a) Interlocking power and bridge devices.
(b) Bridge surfacing, aligning and fastening devices.
(c) Rail-end connections.
(d) Signaling and interlocking.
(e) Guard rails.

Interlocking Power and Bridge Devices.

(a) Interlocking the drawbridge devices so that their movements must follow in a predetermined order to protect the drawbridge machinery.

Bridge Surfacing, Aligning and Fastening Devices.

(b) Drawbridges should be equipped with proper mechanism to surface and align them accurately and fasten them securely in position. This condition can be secured by the use of efficient end lifts in case of swingbridges, and by proper end locks in case of lift bridges.

Rail-End Connections.

(c) Rail ends may be mitered or cut square. Mitered rails where lapped should retain the full thickness of the web to the points. The points should be trailing to normal traffic where possible; on single-track bridges the points should be trailing to traffic entering the movable span.

Where rail ends are cut square or mitered and not lapped, they should be connected by sliding sleeve or joint bars or by easer rails to carry the wheels over the opening between the end of bridge and approach rails.

Signaling and Interlocking.

(d) If trains are to proceed over drawbridges which are in service, without first stopping, interlocking should be installed which will provide that the drawspan, tracks and switches within the limits of the plant are locked in the proper position. This will require:

(1) Locking drawbridge devices.

(2) Locking providing for the proper order of operation of signaling devices, such as signals, switches and derails.

---

[7] Adopted, Vol. 17, 1916, pp. 101, 172, 800.

This interlocking will require the following order of operation:

Before Opening Drawbridge.	*Before Operating Trains Over Drawbridge.*
1. Display stop signals.	1. Lock bridge and rail devices.
2. Unlock rail and bridge devices.	2. Display clear signals.

Since there are various types and designs of drawbridges and various drawbridge devices for each of the types, and also various designs and types of signaling devices, as well as various locations, from which they all may be interlocked and operated, a typical example only of the detail order of operations is given; viz., a swingbridge with all its devices operated from one location on the drawspan, having home and distant signals, derails, etc.:

To Open Drawbridge.	*To Pass Trains Over Drawbridge.*
1. Display stop signals.	1. Close bridge.
2. Unlock derails.	2. Insert bridge surfacing, aligning and fastening devices.
3. Open derails.	3. Insert rail-end connections.
4. Uncouple interlocking connections.	4. Operate power-controlling device to position preventing application of power to bridge machinery.
5. Unlock rail-end connections.	5. Lock bridge surfacing, aligning and fastening devices.
6. Unlock bridge surfacing, aligning and fastening devices.	6. Lock rail-end connections.
7. Operate power-controlling device to position permitting application of power to bridge machinery.	7. Couple interlocking connections.
8. Withdraw rail-end connections.	8. Close derails.
9. Withdraw bridge surfacing, aligning and fastening devices.	9. Lock derails.
10. Open bridge.	10. Display clear signal.

DERAILS.—The above example of order of operation includes derailing switches, but their use is not recommended in all cases. Each situation must be given special study with respect to: (a) the use of derails, smash boards or similar devices; (b) their location with respect to drawspan, and (c) the use and length of guard rails.

Guard Rails.

(e) Guard rails should be provided as for fixed bridges, except for the necessary breaks at the ends of the movable span. Obstructions to derailed wheels which are guided by the guard rails should be reduced to a minimum.

The rails and attachments should be separated from the metallic structure so track circuits may be successfully operated the entire length of the bridge.

The various bridge devices should be so designed that Railway Signal Association interlocking apparatus may be used.

Electric and time locking are regarded as adjuncts.

[8] SPECIFICATIONS FOR BRONZE BEARING METALS FOR TURNTABLES AND MOVABLE RAILWAY BRIDGES.

1. Phosphor bronze shall be a homogeneous alloy of crystalline structure. It shall be made from new metals, except that scrap of known composition produced by the foundry at which the bronze is cast may be used. It shall not contain sulphur. The phosphorus shall be introduced in the form of phosphor-tin or phosphor-copper. Castings shall be sound, clean, and free from blowholes, porous places, cracks and other defects.

2. The alloy shall be cast into ingots and allowed to cool, and the castings shall be poured from the remelted ingots. Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

3. There shall be four grades:

Grade A is to be used for contact with hardened steel discs under pressures exceeding 1500 lb. per sq. in., such as are used in turntables and center bearing swingbridges.

Grade B is to be used for contact with soft steel at low speeds under pressures not exceeding 1500 lb. per sq. in., such as trunnions and journals of bascule and lift bridges.

Grade C is to be used for ordinary machinery bearings.

Grade D is to be used for gears, worm wheels, nuts, and similar parts which are subjected to other than compressive stresses.

4. The chemical and physical qualities shall conform with the requirements in the table on the following page.

5. The chemical analysis of each heat shall be furnished.

---

[8] Adopted, Vol. 19, 1918, pp. 812, 813, 1191.

6. Test specimens shall be made from coupons which are a part of the casting and which have been fed and cooled under the same conditions as the casting.

7. Compression test specimens shall be cylinders one inch high and of one square inch area. The elastic limit in compression shall be the load which gives a permanent set of 0.001 inch.

8. Tension test specimens shall be turned from a coupon not less than one inch in diameter to the form shown in Fig. 5 of the American Railway Engineering Association General Specifications for Steel Railway Bridges. The diameter of the turned specimen shall be one-half inch.

9. At least one compression test shall be made from each melt for grades A, B, and C; and one compression and one tension test for grade D. For castings weighing over 100 lb., finished, the prescribed tests shall be made for each casting.

10. The hardness of the finished castings shall be tested by the Brinell ball method and a record of the test furnished. The ball shall be of hardened steel 10 mm. in diameter. The load shall be 500 kg. and shall be applied for 30 seconds to a finished plane surface. At least two hardness tests shall be made upon each heat. A test shall be made on each trunnion bearing and each disc.

CHEMICAL AND PHYSICAL QUALITIES.

	Grade			
	A	B	C	D
Alloy of	Copper and tin	Copper and tin	Copper, tin and lead	Copper, tin and zinc
Copper per cent	......	......	82 max.	89 max.
Tin per cent	20 max.	17 max.	11 max.	11 max.
Lead per cent	......	......	11 max.	......
Zinc per cent	......	......	......	2.25 max.
Phosphorus per cent	1.0 max.	1.0 max.	1.0 max. 0.7 min.	0.25 max.
Other elements per cent	0.5 max.	0.5 max.	0.5 max.	0.5 max.
Elastic limit in compression, lb. per sq. in.	24000 min.	18000 min.	......	......
Permanent set under 100,000 lb	.06 min. .10 max.	.10 min. .20 max.	......	......
Permanent set under 50,000 lb	To be recorded	To be recorded	To be recorded	To be recorded
Yield point in tension, lb. per sq. in.	......	......	......	To be recorded
Ultimate strength in tension, lb. per sq. in.	......	......	......	33000 min.
Elongation in 2 in. per cent	......	......	......	14 min.

Cracks or other evidence of excessive brittleness in compression test specimens after load may be cause for rejection.

[9] CONTRACTING FOR STEEL RAILWAY BRIDGES.

It is recommended that railway companies:

(1) Furnish general detailed plans and specifications of structural work to bidders, complete enough to show the exact character of the work. If such plans cannot be furnished, the alternative should be full specifications, accompanied by outline plans and complete information concerning the work.

(2) Invite bids on a pound price basis. If desired, alternate bids may be asked for the work, f. o. b. cars, and for the work erected. A lump sum bid is inadmissible unless general detailed plans and specifications are furnished.

(3) Invite bids for as large groups of bridges as can be defined consistently with the first recommendation. When necessary to anticipate future requirements, the railway company need not submit designs if the nature of the work is known to the bidder by reason of similar work previously performed by him for the railway, or if designs of similar structures are submitted to the bidders.

(4) Erect bridges with their own forces on lines where traffic is to be maintained. On small railways where suitably organized and equipped forces for such work may not be justified, the large bridges, and in some cases all bridges, may be erected by contract.

(5) Furnish and lay the floor timber in all cases.

[10] SPECIFICATIONS FOR THE ERECTION OF RAILWAY BRIDGES.

(NOTE.—Proposed revision of these specifications are shown in Vol. 23, Proceedings for 1922.)

Work to Be Done.

1. The Contractor shall erect, rivet and adjust all metal work in place complete, and perform all other work hereinafter specified.

Plant.

2. The Contractor shall provide all tools, machinery and appliances necessary for the expeditious handling of the work, including drift pins and fitting up bolts.

Falsework.

3. The method of erection and plans for falsework and erection equipment shall be subject to approval by the Engineer, but such approval shall not relieve the Contractor from any responsibility. Falsework will

---

[9] Adopted, Vol. 7, 1906, pp. 184, 263, 264; Vol. 11, Part 1, 1910, pp. 115, 160.

[10] Adopted, Vol. 13, 1912, pp. 83-87, 935-945.

be built by *............................. Falsework material of every character will be provided by the *...............................

The temporary structure for use during erection and for maintaining the traffic shall be properly designed and substantially constructed for the loads which will come upon it. All bents shall be thoroughy secured against movement, both transversely and longitudinally. The bents shall be well secured against settling, and piles used wherever firm bottom cannot be obtained. Upon completion of the erection, the temporary structure, if the property of the Railway Company, shall be removed without unnecessary damage, and neatly piled near the site or loaded on cars, as may be directed. If the property of the Contractor, it shall be removed in a manner subject to the approval of the Engineer.

Falsework placed by the Railway Company under an old structure or for carrying traffic, may be used as far as practicable by the Contractor during erection, but it shall not be unnecessarily cut or wasted.

Conduct of Work.

4. The work shall be prosecuted with sufficient force, plant and equipment to expedite its completion to the utmost extent and in such a manner as to be at all times subordinate to the use of the tracks by the Railway Company, and so as not to interfere with the work of other contractors, or to close or obstruct any thoroughfare by land or water, except under proper authority.

Reasonable reduction of speed will be allowed upon request of the Contractor.

Tracks shall not be cut nor shall trains be subjected to any stoppage except when specifically authorized by the Engineer.

The Contractor shall protect traffic and his work by flagmen furnished by and at the expense of the Railway Company. The Contractor shall provide competent watchmen to guard the work and material against injury.

Engine Service.

5. If under the contract, work train or engine service is furnished the Contractor free of charge, such service shall consist only in unloading materials and in transferring the same from a convenient siding to the bridge site. Other engine service shall be paid for by the Contractor at the rate of $.............. per day per engine, the time to include the time necessary for the engine to come from and return to its terminal. When engine service is desired the Contractor shall give the proper rail-

---

* Insert "Railway Company" or "Contractor," as the case may be.

way officials at least 24 hours' advance notice and the Railway Company will furnish the service as promptly as possible, consistent with railroad operations.

When derrick cars are used on main tracks, their movements shall be in charge of a train crew, and the expense of the crew and any engine service other than as noted above shall be charged to the Contractor.

Transportation.

6. When transportation of equipment, materials and men is furnished free over the Railway Company's line, it shall be subject to such conditions as may be stated in the contract.

Masonry.

7. The Railway Company will furnish all masonry to correct lines and elevations, and unless otherwise stated in the contract, will make all changes in old masonry without unnecessarily impeding the operations of the Contractor. The Railway Company's Engineer will establish lines and elevations and assume responsibility therefor, but the Contractor shall compare the elevations, distances, etc., shown on plans, with the masonry as actually constructed as far as practicable, before he assembles the steel. In case of discrepancy, he shall immediately notify the Engineer.

Handling and Storing of Materials.

8. Cars containing materials or plant shall be promptly unloaded upon delivery therefor, and in case of failure to do so the Contractor shall be liable for demurrage charges. Material shall be placed on skids above the ground, laid so as not to hold water, and stored and handled in such a manner as not to be injured or to interfere with railroad operations. The expense of repairing or replacing material damaged by rough handling shall be charged to the Contractor. The Contractor, while unloading and storing material, shall compare each piece with the shipping list and promptly report any shortage or injury discovered.

Maintenance of Traffic.

9. When traffic is to be maintained it will be carried on in such a manner as to interfere as little as practicable with the work of the Contractor.

Changes in the supporting structure or tracks required during erection shall be at all times under the direct control and supervision of the Railway Company.

Removal of Old Structure.

10. Unless otherwise specified, metal work in the old structure shall

be dismantled without unnecessary damage and loaded on cars or neatly piled at a site immediately adjacent to the tracks, and at a convenient grade for future handling, as may be directed. When the structure is to be used elsewhere all parts will be match-marked by the Railway Company; when the old bridge is composed of several spans the parts of each shall be kept separate.

Metal Work.

11. Material shall be handled without damage. Threads of all pins shall be protected by pilot and driving nuts while being driven in place.

Light drifting will be permitted in order to draw the parts together, but drifting for the purpose of matching unfair holes will not be permitted. Unfair holes shall be reamed or drilled.

Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

All splices and field connections shall be securely bolted prior to riveting. When the parts are required to carry traffic, important connections, such as attachments of stringers and floor beams, shall have at least 50 per cent. of the holes filled with bolts and 25 per cent. with drift pins. All tension splices shall be riveted up complete before blocking is removed. When not carrying traffic, at least 33⅓ per cent. of the holes shall have bolts.

Rivets in splices of compression members shall not be driven until the members shall have been subjected to full dead load stresses. Rivets shall be driven tight. No recupping or caulking will be permitted. The heads shall be full and uniform in size and free from fins, concentric and in full contact with the metal. Heads shall be painted immediately after acceptance.

Rivets shall be uniformly and thoroughly heated and no burnt rivets shall be driven. All defective rivets shall be promptly cut out and redriven. In removing rivets the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out.

Misfits.

12. Correction of minor misfits and a reasonable amount of reaming shall be considered as a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, and a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Engineer and the work of correction done in the presence of the Engineer, who shall check the time expended.

The Contractor shall render an itemized bill for such work of correction for the approval of the Engineer.

Anchor Bolts.

13. Holes for all anchor bolts, except where bolts are built up with the masonry, shall be drilled by the Contractor after the metal is in place and the bolts shall be set in Portland cement grout.

Bed Plates.

14. Bed plates resting on masonry shall be set level and have a full even bearing over their entire surface; this shall be attained by either the use of Portland cement grout or mortar, or by tightly ramming in rust cement under the bed plates after blocking them accurately in position.

Decks.

15. The *......................... will frame and place the permanent timber deck.

Painting.

16. The paint will be furnished by *....................... and shall be of such color, quality and manufacture as may be specified.

Surfaces inaccessible after erection, such as bottoms of base plates, tops of stringers, etc., shall receive two coats of paint before assembling in place. After erection, the entire structure shall receive two coats of paint, allowing enough time between coats for the first coat to dry before applying the second. No paint shall be applied in wet or freezing weather, nor when the surface of the metal is damp. Painting shall be done in good and workmanlike manner, subject to strict inspection during progress and after completion, and in accordance with special instructions which shall be given by the Engineer. All metal shall be thoroughly cleaned of dirt, rust, loose scale, etc., before the paint is applied.

Clearing the Site.

17. The Contractor, after completion of the work of erection, shall remove all old material and débris resulting from his operations and place the premises in a neat condition.

Superintendence and Workmen.

18. During the entire progress of the work the Contractor shall have a competent superintendent in personal charge and shall employ only skilled and competent workmen. Instructions given by the Engineer to the superintendent shall be carried out the same as if given to the Contractor. If any of the contractor's employés by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the Engineer, be discharged from the work, nor thereafter be employed upon it without the Engineer's consent.

---

* Insert "Railway Company" or "Contractor," as the case may be.

Inspection.

19. The work of erection shall at all times be subject to the inspection and acceptance of the Engineer.

Engineer.

20. The term "Engineer," as used herein, shall be understood to mean the Chief Engineer of the Railway Company, or his accredited representative.

[11] GENERAL SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

For Fixed Spans Less Than 300 Feet in Length

1920

Note.—The purpose of the Committee which wrote these specifications was to formulate specific and detailed rules for the design and manufacture of bridges, as a guide to both the designer and the shop, rather than to confine the specifications to a statement of principles or to limit them to rules defining the duties of the contractor. The intention was to describe the best general practice for standard American and Canadian railways, and to advance somewhat the causes of good design and workmanship. The requirements of light and branch railways and foreign practice have not been considered.

The Clearance Diagram in these specifications is intended to be applied to New Construction Work only. It provides for the future development of motive power to a width of eleven feet.

Information to Be Given Bidders.

Article

1. What is the live load to be used?............................ 20
2. Is the bridge on a tangent or curve?......................... 13
   If on a curve, what is the superelevation of the outer rail and what is the degree of the curve?
3. What is the rate and the direction of grade on the bridge?.... 93
4. What are the conditions at the site?......................... 2
   Furnish plans showing the general dimensions necessary for designing the structure:
      Length of spans
      Types of spans
      Number and spacing of tracks
      Angle of skew
      Type of floor
      Limiting under-clearance
5. Shall the work be "Punched Work" or "Reamed Work?".....206
6. What size of rivets shall be used?........................... 59
7. What kind of shop paint will be approved?...................269
8. Will other than two pilot nuts and two driving nuts be required for each size of pin?.....................................256

---

[11] Adopted, Vol. 21, 1920, pp. 491, 1414.

(1) Proposals and Drawings.

Definitions of Terms.

1. The term "Engineer" refers to the Chief Engineer of the Company or his subordinates in authority. The term "Inspector" refers to the inspector or inspectors representing the Company. The term "Company" refers to the Railway Company or Railroad Company party to the contract. The term "Contractor" refers to the manufacturing or fabricating contractor party to the contract.

Proposals.

2. Bidders shall submit proposals to conform with the terms in the letter of invitation. The proposals preferably shall be based upon plans and specifications furnished by the Company showing the general dimensions necessary for designing the structure, the stresses and the general or typical details. Invitations covering work to be designed or erected by the Contractor shall state the general conditions at the site, such as track spacing, character of foundations, old structures, traffic conditions, etc.

Drawings to Govern.

3. Where the drawings and the specifications differ, the drawings shall govern.

Patented Devices.

4. The Contractor shall protect the Company against claims on account of patented devices or parts proposed by him.

Drawings.

5. After the contract has been awarded and before any work is commenced, the Contractor shall submit to the Engineer for approval duplicate prints of stress sheets and shop drawings, unless such drawings shall have been prepared by the Company. The tracings of these drawings shall be the property of and be delivered to the Company after the completion of the contract. Shop drawings shall be made on the dull side of the tracing cloth, 24 by 36 inches in size, including margins. The margin at the left end shall be 1½ inches wide, and the others ½-inch. The title shall be in the lower right-hand corner. No changes shall be made on any approved drawing without the consent, in writing, of the Engineer.

6. The Contractor shall be responsible for the correctness of his drawings, and for shop fits and field connections, although the drawings may have been approved by the Engineer.

7. Any material ordered by the Contractor prior to the approval of the drawings shall be at his risk.

(2) General Features of Design.

Materials Used.

8. Structures shall be made wholly of structural steel except where otherwise specified. Cast steel preferably shall be used for

shoes and bearings. Cast iron may be used only where specifically authorized by the Engineer.

Types of Bridges.

9. The different types of bridges may be used as follows:

Rolled beams for spans up to 35 feet.
Plate girders for spans from 30 feet to 125 feet.
Riveted trusses for spans from 100 feet to 300 feet.
Pin-connected trusses for spans from 150 feet to 300 feet.

Number of Trusses.

10. Unless otherwise specified, double-track through bridges shall have only two trusses or girders, and four-track bridges three.

Dimensions for Calculation.

11. The dimensions for the calculation of stresses shall be as follows:

SPAN LENGTH.

For trusses and girders, the distance center to center of end bearings.

For floor beams, the distance center to center of trusses or girders.

For stringers, the distance center to center of floor beams.

DEPTH.

For riveted trusses, the distance between centers of gravity of chord sections.

For pin-connected trusses, the distance center to center of chord pins.

For plate girders, floor beams and stringers, the distance between centers of gravity of flanges, but not to exceed the distance back to back of the flange angles.

Spacing of Trusses, Girders and Floorbeams.

12. The width center to center of girders or trusses shall be not less than one-fifteenth of the effective span, and not less than is necessary to prevent overturning under the assumed lateral loading. Panel lengths shall not exceed 1½ times the width c. to c. of trusses or girders.

Clearances.

13. If the alinement is straight, clearances shall be not less than shown on the diagram, Fig. 1. If the alinement is curved, the width of the diagram shall be increased so as to provide the same minimum clearances for a car 80 feet long, 14 feet high and 60 feet center to center of trucks, allowance being made for curvature and superelevation of rails. The height of rail shall be assumed as 6 inches.

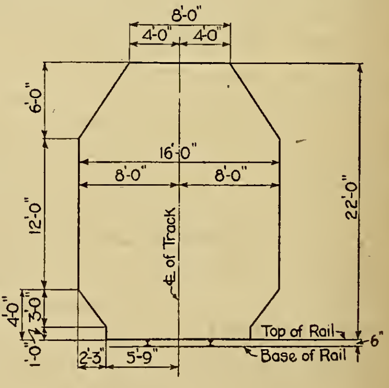


FIG. 1.

Deck Spans on Curves.

14. Deck spans on curves shall have the center line of the span placed, usually, so as to bisect the middle ordinate of and be parallel with the chord of the curve.

Skew Bridges.

15. In skew bridges without ballasted floors, the ends of stringers or girders for each track shall be square with the track.

Ambiguity of Stress.

16. Structures shall be designed so as to avoid, as far as practicable, ambiguity in the determination of the stresses.

(3) Loads

Loads.

17. The structures shall be proportioned for the following loads:

a. The dead load.
b. The live load.
c. The impact or dynamic effect of the live load.
d. The lateral loads and forces.
e. The centrifugal force, including impact.
f. The longitudinal force.

Stresses due to these loads and forces shall be shown separately on the stress sheets.

18. Members shall be proportioned for that combination of stresses which gives the maximum total stress, except as otherwise provided.

Dead Load.

19. The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ pounds per foot B. M., ballast 120 pounds per cubic foot, reinforced concrete 150 pounds per cubic foot, waterproofing 150 pounds per cubic foot, and rails and fastenings 150 pounds per linear foot of track. If ballast is used, it shall be assumed level with the base of rail and the weight of the ties shall be neglected. Ballasted floors shall have at least 6 inches of ballast under the ties.

Live Load.

20. The minimum live load for each track shall be as shown in Figs. 2 and 3, except as modified in Article 21.

The loading that gives the larger stresses shall be used.

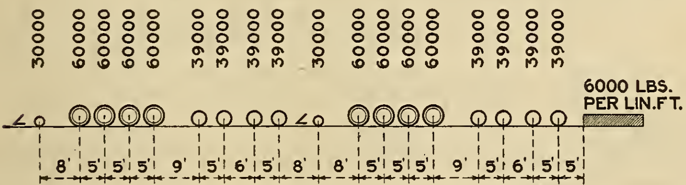


FIG. 2.

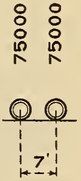


FIG. 3.

21. In special locations, where the conditions limit the loading to light engines, a lighter loading, as stipulated by the Engineer, may be used, but not in any case lighter than three-fourths of that specified in Article 20.

22. Other live loadings shall be proportional to the loading specified in Article 20 with the same wheel spacing.

Multiple Tracks.

23. In calculating the maximum stresses due to live load and centrifugal force when two, three or four tracks are simultaneously loaded, use the following percentages of the specified live load:

For two tracks, loaded, 90 per cent.
For three tracks, loaded, 80 per cent.
For four tracks, loaded, 75 per cent.

Floors.

24. Wooden ties shall be designed for the maximum wheel load specified distributed over three ties and with 100 per cent. impact added. The fiber stress shall not exceed 2,000 pounds per square inch. The ties shall be not less than 10 feet in length. They shall be placed with openings not to exceed 4 inches in width and shall be secured against bunching. The maximum dap of ties shall be 1¼ inches.

25. Floors consisting of beams transverse to the axis of the structure shall be designed for a uniform live load of 15,000 pounds per linear foot for each track, when the minimum live load specified in Article 20 is used. When heavier loadings are used, this uniform load shall be increased proportionately.

26. Floors consisting of longitudinal beams shall be designed for the wheel loads specified.

27. In ballasted floor bridges, the live load shall be considered as uniformly distributed laterally over a width of 10 feet.

Impact.

28. The dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula,

$$I = S\,\frac{300}{300 + \dfrac{L^2}{100}}, \text{ in which}$$

I = impact or dynamic increment to be added to the live-load stress.
S = computed maximum live-load stress.
L = the length in feet of the portion of the span which is loaded to produce the maximum stress in the member.

29. For bridges designed exclusively for electric traction, the impact stresses shall be taken as one-half of those given by the formula in Article 28.

30. Impact shall not be added to stresses produced by longitudinal or lateral forces.

Eccentricity of Load on Curves.

31. For bridges on curves, provision shall be made for the increased load carried by any truss, girder or stringer due to the eccentricity of the load.

Lateral Forces.

32. The lateral (or wind) force shall consist of a moving load equal to 30 pounds per square foot on 1½ times the vertical projection of the structure on a plane parallel with its axis (but never less than 200 pounds per linear foot at the loaded chord, and 150 pounds per linear foot at the unloaded chord), and a moving load of 700 pounds per linear foot applied 8 feet above the base of rail.

33. If a moving load of 50 pounds per square foot on 1½ times the vertical projection of the unloaded structure on a plane parallel with its axis produces greater stresses than the lateral force defined in Article 32, it shall be provided for.

34. In calculating the stresses in viaduct towers due to lateral force, the viaduct shall be considered as loaded on either one or both tracks, with empty cars weighing 1,200 pounds per linear foot.

35. The lateral bracing between compression chords or flanges shall be capable of resisting a transverse shear in any panel equal to 2½ per cent. of the total axial stress in the chords in that panel.

Centrifugal Force.

36. On curves, the centrifugal force (assumed to act 6 feet above the rail) shall be taken equal to a percentage of the live load including impact according to the following table:

Degree of Curve............	0° 20′	0° 40′	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
Percentage.................	2½	5	7½	10	10	10	10	10	10	10	10	10	10	10
Speed in miles per hour....	80	80	80	65	53	46	41	38	35	33	31	29	28	27

Longitudinal Force.

37. Provision shall be made in the design for the effect of a longitudinal force of 20 per cent. of the live load on one track only, applied 6 feet above the top of the rail. In structures (such as ballasted deck bridges of only three or four spans) where, by reason of continuity of members or frictional resistance, the longitudinal force will be largely directed to the abutments, its effect on the superstructure shall be taken as one-half that specified above.

(4) Unit Stresses and Proportioning of Parts.

38. The several parts of structures shall be so proportioned that the unit stresses will not exceed the following, except as modified in Articles 46 and 47:

	Pounds per sq. inch
Axial tension, net section	16,000
Axial compression, gross section	$15{,}000 - 50\frac{l}{r}$
but not to exceed	12,500
l = the length of the member in inches.	
r = the least radius of gyration of the member in inches.	
Tension in extreme fibers of rolled shapes, built sections and girders, net section	16,000
Tension in extreme fibers of pins	24,000
Shear in plate girder, webs, gross section	10,000
Horizontal shear in flange angles of girders	4,000
Shear in power-driven rivets and pins	12,000
Bearing on power-driven rivets, pins, outstanding legs of stiffener angles, and other steel parts in contact	24,000

The above mentioned values for shear and bearing shall be reduced 25 per cent. for countersunk rivets, hand-driven rivets, floor-connection rivets, and turned bolts.

Bearing on expansion rollers, per linear inch........600*d*

d = the diameter of rollers in inches.

	Pounds per sq. inch
Bearing on granite masonry	800
Bearing on sandstone and limestone masonry	400
Bearing on concrete masonry	600

39. For cast steel in shoes and bearings, the above mentioned unit stresses shall apply.

40. The diagonal tension in webs of girders and rolled beams at sections where maximum shear and bending occur simultaneously, shall not exceed 16,000 pounds per square inch.

Effective Bearing Area.

41. The effective bearing area of a pin, a bolt or a rivet shall be its diameter multiplied by the thickness of the piece, except that for countersunk rivets, half the depth of the countersink shall be omitted.

Effective Diameter of Rivets.

42. In proportioning rivets, the nominal diameter of the rivet shall be used.

Proportioning Web Members.

43. In proportioning web members of trusses, use two-thirds of the dead load stress plus one and one-sixth times the live load stress, including impact, where this sum is greater than the sum of the dead load stress and the live load stress, including impact.

Reversal of Stress.

44. Members subject to reversal of stress under the passage of the live load shall be proportioned as follows:

Determine the resultant tensile stress and the resultant compressive stress and increase each by 50 per cent. of the smaller; then proportion the member so that it will be capable of resisting either increased resultant stress. The connections shall be proportioned for the sum of the resultant stresses.

Combined Stresses.

45. Members subject to both axial and bending stresses (including bending due to floor beam deflection) shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress. In members continuous over panel points, only three-fourths of the bending stress computed as for simple beams shall be added to the axial stress.

46. Members subject to stresses produced by a combination of dead load, live load, impact and centrifugal force, with either lateral or longitudinal forces, or bending due to lateral action, may be proportioned for unit stresses 25 per cent. greater than those specified in Article 38; but the section shall not be less than that required for dead load, live load, impact and centrifugal force.

Secondary Stresses.

47. Designing and detailing shall be done so as to avoid secondary stresses as far as possible. In ordinary trusses without subpanelling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of its length. Where this ratio is exceeded, or where subpanelling is used, secondary stresses due to deflection of the truss shall be computed. The unit stresses specified in Article 38 may be increased one-third for a combination of the secondary stresses with the other stresses, but the section shall not be less than that required when secondary stresses are not considered.

Compression Flanges.

48. The gross area of the compression flanges of plate girders and rolled beams shall not be less than the gross area of the tension flanges, but the stress per square inch shall not exceed

$$16{,}000 - 150\frac{l}{b}, \text{ in which}$$

$l =$ the length of the unsupported flange, between lateral connections or knee braces.
$b =$ the flange width.

(5) Details of Design.

Limiting Lengths of Members.

49. The ratio of length to least radius of gyration shall not exceed 100 for main compression members nor 120 for wind and sway bracing.

50. The lengths of riveted tension members shall not exceed 200 times their least radius of gyration.

Depth Ratios.

51. The depth of trusses preferably shall be not less than one-tenth of the span. The depth of plate girders preferably shall be not less than one-twelfth of the span. The depth of rolled beams used as girders and the depth of solid floors preferably shall be not less than one-fifteenth of the span. If less depths than these are used, the section must be increased so that the maximum deflection will not be greater than if these limiting ratios had not been exceeded.

Parts Accessible.

52. Details shall be designed so that all parts will be accessible for inspection, cleaning and painting. Closed sections shall be avoided wherever possible.

Pockets.

53. Pockets or depressions which would hold water shall have efficient drain holes, or shall be filled with concrete.

Eccentric Connections.

54. Members shall be connected so that their gravity axes will intersect in a point. Eccentric connections shall be avoided if practicable, but, if unavoidable, the members shall be proportioned so that the combined fiber stress will not exceed the allowed axial stress.

Effective Area of Angles.

55. The effective area of single angles in tension shall be assumed as the net area of the connected leg plus 50 per cent. of the area of the unconnected leg. Single angles connected by lug angles shall be considered as connected by one leg.

Counters.

56. If web members are subject to reversal of stress, their end connections preferably shall be riveted. Adjustable counters shall have open turnbuckles.

Strength of Connections.

57. Connections shall have a strength at least equal to that of the members connected, regardless of the computed stress. Connections shall be made, as nearly as practicable, symmetrical about the axis of the members.

Limiting Thickness of Metal.

58. Metal shall not be less than ⅜-inch thick, except for fillers. Metal subject to marked corrosive influences shall be increased in thickness or protected against such influences.

Sizes of Rivets.

59. Rivets shall be ¾ inch, ⅞ inch or 1 inch in diameter, as specified.

Pitch of Rivets.

60. The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance preferably shall be not less than 3½ inches for 1 inch rivets, 3 inches for ⅞-inch rivets and 2½ inches for ¾-inch rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 7 inches for 1 inch rivets, 6 inches for ⅞-inch rivets and 5 inches for ¾-inch rivets. For angles with two gage lines and rivets staggered, the maximum pitch in each line shall be twice the amounts given above. If two or more web plates are used in contact, stitch rivets shall be provided to make them act in unison. In compression members, the stitch rivets shall be spaced not more than 24 times the thickness of the thinnest plate in the direction perpendicular to the line of stress, and not more than 12 times the thickness of the thinnest plate in the line of stress. In tension members, the stitch rivets shall be not more than 24 times the thickness of the thinnest outer plate in either direction. In tension members composed of two angles in contact, a pitch of 12 inches may be used for riveting the angles together.

Edge Distance.

61. The minimum distance from the center of any rivet hole to a sheared edge shall be: 1¾ inches for 1 inch rivets, 1½ inches for ⅞-inch rivets and 1¼ inches for ¾-inch rivets; to a rolled edge 1½ inches, 1¼ inches and 1⅛ inches, respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 inches.

Size of Rivets in Angles.

62. The diameter of the rivets in any angle whose size is determined by calculated stress shall not exceed one-fourth of the width of the leg in which they are driven. In angles whose size is not so determined 1 inch rivets may be used in 3½ inch legs, ⅞-inch rivets in 3 inch legs, and ¾-inch rivets in 2½ inch legs.

Long Rivets.

63. Rivets which carry calculated stress and whose grip exceeds four and one-half diameters shall be increased in number at least one per cent. for each additional $\frac{1}{16}$-inch of grip. If the grip exceeds six times the diameter of the rivet, specially designed rivets shall be used.

Pitch of Rivets at Ends.

64. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivet for a distance equal to one and one-half times the maximum width of the member.

Compression Members.

65. In built compression members, the metal shall be concentrated in the webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between the lines of rivets

connecting it to the flanges. The thickness of cover plates shall be not less than one-fortieth of the distance between the nearest rivet lines.

Outstanding Legs of Angles.

66. The width of the outstanding legs of angles in compression (except when reinforced by plates) shall not exceed the following:

a. For stringer flange angles, ten times the thickness.

b. For main members carrying axial stress, twelve times the thickness.

c. For bracing and other secondary members, fourteen times the thickness.

Stay Plates.

67. The open sides of compression members shall be provided with lacing bars and shall have stay plates as near each end as practicable. Stay plates shall be provided at intermediate points where the lacing is interrupted. In main members, the length of the stay plates shall be not less than 1¼ times the distance between the lines of rivets connecting them to the outer flanges, and the length of intermediate stay plates shall be not less than three-quarters of that distance. Their thickness shall be not less than one-fiftieth of the same distance.

68. Tension members composed of shapes shall have their separate segments stayed together. The stay plates shall have a length not less than two-thirds of the lengths specified for stay plates on compression members.

Lacing.

69. The lacing of compression members shall be proportioned to resist a shearing stress of 2½ per cent. of the direct stress. The minimum width of lacing bars shall be 3 inches for 1 inch rivets, 2¾ inches for ⅞-inch rivets, 2½ inches for ¾-inch rivets, and 2 inches for ⅝-inch rivets. The thickness shall be made as required by Article 38, in which “l” shall be taken as the distance between connections to the main sections.

70. In members composed of side segments and a cover plate, with the open side laced, one-half the shear shall be considered as taken by the lacing. Where double lacing is used, the shear in the plane of the lacing shall be equally distributed between the two systems.

71. Lacing bars of compression members shall be so spaced that the $\frac{l}{r}$ of the portion of the flange included between their connections will be not greater than 40, and not greater than two-thirds of the $\frac{l}{r}$ of the member.

72. In connecting lacing bars to flanges, ⅝-inch rivets shall be used for flanges less than 2½ inches wide, ¾-inch rivets for flanges

from 2½ to 3½ inches wide, and ⅞-inch rivets for flanges 3½ or more inches wide. Lacing bars with at least two rivets in each end shall be used for flanges over 5 inches wide.

73. The angle of lacing bars with the axis of the member shall be not less than 45 degrees for double lacing, and 60 degrees for single lacing. If the distance between rivet lines in the flanges is more than 15 inches and a single-rivet bar is used, the lacing shall be double and riveted at the intersections.

Splices.

74. Abutting joints in compression members faced for bearing shall be spliced on four sides. The gross area of the splice material shall be not less than 50 per cent. of the gross area of the smaller member.

75. Joints in riveted work not faced for bearing, whether in tension or compression, shall be fully spliced.

Net Section at Pins.

76. In pin connected riveted tension members, the net section across the pin hole shall be not less than 140 per cent. and the net section back of the pin hole not less than 100 per cent. of the net section of the body of the member, and there shall be sufficient rivets to make the material effective.

Net Section Defined.

77. The net section of riveted members shall be the least area which can be obtained by deducting from the gross sectional area the areas of holes cut by any plane perpendicular to the axis of the member and parts of the areas of other holes on one side of the plane within a distance of four inches, which are on gage lines one inch or more from those of the holes cut by the plane, the parts being determined by the formula:

$$A\left[1-\frac{P}{4}\right], \text{ in which}$$

$A =$ the area of the hole.

$P =$ the distance in inches of the center of the hole from the plane.

78. In determining the net section, the diameter of the rivet hole shall be taken one-eighth-inch larger than the nominal diameter of the rivet.

Pin Plates.

79. Where necessary to give the required section or bearing area, pin holes shall be reinforced on each segment by plates, one of which on each side must be as wide as the outstanding flanges will permit. These plates shall contain enough rivets and be so connected as to transmit and distribute the bearing pressure uniformly over the full cross-section and to reduce the eccentricity of the segment to a minimum. At least one full-width plate on each segment shall extend to

the far edge of the stay plate and the others not less than 6 inches beyond the near edge.

Indirect Splices.

80. If splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number required in the case of direct contact to the extent of two extra lines for each intervening plate.

Fillers.

81. Where rivets carrying stress pass through fillers, the fillers shall be extended beyond the connected member and the extension sesured by additional rivets sufficient to develop the value of the filler.

Forked Ends.

82. Forked ends on compression members will be permitted only where unavoidable. Where forked ends are used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member and they shall be extended as far as necessary in order to carry the stress of the main member into the jaws, but shall not be shorter than required by Article 79.

Pins.

83. Pins shall be long enough to secure a full bearing of all parts connected upon the turned body of the pin. They shall be secured by chambered nuts or by solid nuts with washers. Where the pins are bored, through rods with cap washers may be used. The screw ends shall be long enough to admit of burring the threads.

84. Pin connected members shall be held against lateral movement on the pins.

Bolts.

85. Where members are connected by bolts, the turned bodies of the bolts shall be long enough to extend through the metal. A washer at least ¼-inch thick shall be used under the nut. Bolts shall not be used except by special permission.

Upset Ends.

86. Bars with screw ends shall be upset so that the area at the root of the thread will be at least 15 per cent. larger than in the body of the bar.

Sleeve Nuts.

87. Sleeve nuts shall not be used.

Expansion.

88. Provision shall be made for expansion and contraction at the rate of one inch for every 100 feet in length. The expansion ends shall be secured against lateral movement. In spans more than 250 feet in length, provision shall be made for expansion in the floor.

Expansion Bearings.

89. Spans more than 70 feet in length shall have rollers at one end. Spans of less length shall be arranged to slide on smooth surfaces.

Fixed Bearings.

90. Bearings and ends of spans shall be secured against lateral motion.

Rollers.

91. Expansion rollers shall be not less than 6 inches in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be cleaned readily. Rollers shall be geared to the upper and lower plates.

Pedestals and Shoes.

92. Pedestals and shoes preferably shall be made of cast steel. The difference between the top and bottom bearing widths shall not exceed twice the depth. For hinged bearings, the depth shall be measured from the center of the pin. Where built pedestals and shoes are used, the web plates and the angles connecting them to the base plate shall be not less than ¾-inch thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely. The minimum thickness of the metal in cast steel pedestals shall be one inch. Pedestals and shoes shall be so constructed that the load will be distributed uniformly over the entire bearing. Spans more than 70 feet in length shall have hinged bearings at each end.

Inclined Bearings.

93. For spans on an inclined grade and without hinged bearings, the sole or masonry plates shall be beveled so that the masonry surfaces will be level.

Name Plates.

94. There shall be a name plate, showing in raised letters and figures the name of the manufacturer and the year of construction, bolted to the bridge near each end at a point convenient for inspection.

(6) Floors.

Types of Floors.

95. Floors may consist of steel floor-beams and stringers, with timber cross-ties supporting the rails, or of one of the solid floor types.

Floor Members.

96. Floor members shall be designed with special reference to stiffness.

97. Specifications for plate girders shall apply to floor-beams and stringers.

Spacing of Stringers.

98. Stringers usually shall be spaced 6 feet 6 inches center to

center. If four stringers are used under one track, each pair shall be spaced symmetrically about the rail.

I-Beam Girders.

99. Rolled beams supporting timber decks shall be arranged with not more than four, and preferably not less than two beams under each rail. The beams in each group shall be placed symmetrically about the rail, and shall be spaced sufficiently far apart to permit cleaning and painting. They shall be connected by solid web diaphragms near the ends and at intermediate points, spaced not over twelve times the flange width. Bearing plates shall be continuous under each group of beams. End stiffeners shall be used if required by the provisions of Article 38.

Floor-Beam Connections.

100. Floor-beams preferably shall be square to the girders or trusses. They shall be riveted directly to the girders or between the posts of through and deck truss spans.

End Connection Angles.

101. The legs of stringer connection angles shall be not less than 4 inches in width, and not less than ⅝-inch in thickness before facing. Shelf angles shall be provided to support the stringers during erection, but the connection angles shall be sufficient to carry the whole load. Stringers in through spans shall be riveted between the floor-beams.

Stringer Frames.

102. Where two lines of stringers are used under each track in panels more than 20 feet in length, they shall be connected by cross frames.

Solid Floor Connections.

103. Solid floors shall be connected to the girders or trusses by angles not less than ⅝-inch thick if to be faced, or ½-inch thick if not to be faced; one angle on each side of the web of I-beams and one on each of the vertical members of troughs. (223)

Proportioning Solid Floors.

104. Solid floors shall be proportioned by the moments of inertia of the sections, using the net sections including the compression side.

(7) Bracing.

Design of Bracing.

105. Lateral, longitudinal and transverse bracing shall be composed of shapes with riveted connections. Lateral bracing shall have concentric connections to chords at end joints, and preferably throughout. The connections between the lateral bracing and the chords shall be designed to avoid, as far as practicable, any bending stress in the truss members.

106. When a double system of bracing is used, both systems may be considered simultaneously effective if the members meet the requirements, both as tension and compression members.

Lateral Bracing.

107. Bottom lateral bracing shall be provided in all bridges except deck plate girder spans less than 50 feet long, from which it may be omitted. Continuous steel or concrete floors will be considered lateral bracing.

108. Top lateral bracing shall be provided in deck spans and in through spans having sufficient head room.

Portal and Sway Bracing.

109. Deck truss spans shall have vertical sway bracing at each panel point. They shall also have bracing in the planes of the end posts. The end reaction of the top lateral system shall be carried through the vertical end bent to the masonry.

110. Through truss spans shall have portal bracing, with knee braces, as deep as the specified clearance will allow.

111. Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit of a depth of 6 feet or more for the bracing. When the height of the trusses will not permit of such depth, the top lateral struts shall be of the same depth as the chord and shall have knee braces.

Cross-Frames.

112. Deck plate girder spans shall be provided with cross-frames at each end proportioned to resist centrifugal and lateral forces, and shall have intermediate cross-frames at intervals not exceeding 18 feet.

Laterals.

113. The smallest angle to be used in lateral bracing shall be 3½ by 3 by ⅜ inches. There shall be not less than three rivets at each end connection of the angles. Angles shall be connected at their intersections by plates.

Clearance.

114. Lateral bracing beneath the track shall be low enough to clear the ties.

(8) Plate Girders.

Spacing of Girders.

115. The girders of deck bridges usually shall be spaced 6 feet 6 inches between centers, except that:

a. In single-track deck spans 75 or more feet in length, the girders shall be spaced in accordance with paragraph 12, but not less than 7 feet 6 inches between centers.

b. In bridges on curves, the girders shall be spaced as shown on the plans.

Design of Plate Girders.

116. Plate girders shall be proportioned either by the moment of inertia of their net section including compression side; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if properly spliced, may be used as flange section. For girders having unusual sections, the moment of inertia method shall be used.

Flange Sections.

117. The flange angles shall form as large a part of the area of the flange as practicable. Side plates shall not be used except when flange angles exceeding one inch in thickness otherwise would be required.

118. Flange plates shall be equal in thickness, or shall diminish in thickness from the flange angles outward. No plate shall have a thickness greater than that of the flange angles.

119. Where flange cover plates are used, one cover plate of the top flange shall extend the full length of the girder. Other flange plates shall extend at least 18 inches beyond the theoretical end.

Thickness of Web Plates.

120. The thickness of web plates shall be not less than $\frac{1}{20}\sqrt{D}$. where "*D*" represents the distance between flanges in inches.

Flange Rivets.

121. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer to the flange section the horizontal shear at any point combined with any load that is applied directly on the flange. One wheel load, where ties rest on the flange, shall be assumed to be distributed over 3 feet.

Flange Splices.

122. Splices in flange members shall not be used except by special permission of the Engineer. Two members shall not be spliced at the same cross-section and, if practicable, splices shall be located at points where there is an excess of section. The net section of the splice shall exceed by 10 per cent. the net section of the member spliced. Flange angle splices shall consist of two angles, one on each side.

Web Splices.

123. Web plates shall be symmetrically spliced by plates on each side. The splice plates for shear shall be of the full depth of the girders between flanges. The splice shall be equal to the web in strength in both shear and moment. There shall be not less than two rows of rivets on each side of the joint.

End Stiffeners.

124. Plate girders shall have stiffener angles over end bearings, the outstanding legs of which will extend as nearly as practicable to the outer edge of the flange angles. These end stiffeners shall be proportioned for bearing of the outstanding legs on the flange angles,

and shall be arranged to transmit the end reaction to the pedestals or distribute it over the masonry bearings. They shall be connected to the web by enough rivets to transmit the reaction. End stiffeners shall not be crimped.

Intermediate Stiffeners.

125. The webs of plate girders shall be stiffened by angles at intervals not greater than:

(a) Six feet.
(b) The depth of the web.
(c) The distance given by the formula $d = \frac{t}{40}(12{,}000 - S)$

d = the distance between rivet lines of stiffeners in inches.
t = the thickness of the web in inches.
S = web shear in pounds per square inch at the point considered.

126. If the depth of the web between the flange angles or side plates is less than 50 times the thickness of the web, intermediate stiffeners may be omitted.

127. Stiffener angles shall be placed at points of concentrated loading. Such angles shall not be crimped.

128. Intermediate stiffeners shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall not be less than 2 inches plus one-thirtieth of the depth of the girder, nor more than 16 times its thickness.

Gusset Plates in Through Girders.

129. In through plate girder spans, the top flanges shall be braced by means of gusset plates or knee braces with solid webs connected to the floor-beams and extending usually to the clearance line. If the unsupported length of the inclined edge of the gusset plate exceeds 18 inches, the gusset plate shall have one or two stiffening angles riveted along its edge. The gusset plate shall be riveted to a stiffener angle on the girder. Preferably it shall form no part of the floor-beam web.

130. In through plate girder spans with solid floors, there shall be knee-braces with ⅜-inch webs, extending usually to the clearance line, at intervals of about 12 feet. Each knee-brace shall be well riveted to the floor and the girder, especially at the top, and shall have its edge reinforced by one or two angles.

Ends of Through Girders.

131. If through plate girders project two feet or more above the base of the rail, the upper corners shall be rounded. In multiple span bridges, usually only the extreme ends shall be rounded. Exposed ends of through girders shall be neatly finished with end plates.

Spans Shipped Riveted.

132. Deck plate girder spans less than 50 feet in length shall be shipped riveted complete, unless otherwise specified.

Masonry Bearings.

133. End bearings on masonry preferably shall be raised above the coping by metal pedestals.

134. Sole plates shall be not less than ¾-inch thick and not less in thickness than the flange plus ⅛-inch. Preferably they shall not be longer than 18 inches.

Anchor Bolts.

135. Anchor bolts shall be 1¼ inches in diameter and shall extend 12 inches into the masonry. There shall be washers under the nuts. Anchor bolt holes in pedestals and sole plates shall be 1⅝ inches in diameter, except that at expansion joints the holes in the sole plates shall be slotted.

(9) Trusses.

Type of Truss and Sections of Members.

136. Trusses shall have single intersection web systems and, preferably, inclined end posts. The top chords and end posts shall be made usually of two side segments with one cover plate and with stay plates and lacing on the open side. The bottom chords of riveted trusses shall be symmetrically made, usually of vertical side plates with flange angles. Web members shall be made of symmetrical sections.

Camber.

137. The length of members of truss spans shall be such that the camber will be equal to the deflection produced by the combined dead and live loads without impact.

Riveted Members in Pin-Connected Trusses.

138. In pin-connected trusses, hip verticals (and members performing similar functions) and, in single track spans, the two panels at each end of the bottom chords shall be riveted members.

Eye-Bars.

139. The cross sectional area of the head through the center of the pin hole shall exceed that of the body of the eye-bar by at least 37½ per cent. The thickness of the bar shall be not less than one-eighth of the width nor less than one inch, and not greater than 2 inches. The form of the head shall be submitted to the Engineer for approval before the bars are made. The diameter of the pin shall be not less than seven-eighths of the width of the widest bar attached.

Packing.

140. The eye-bars of a set shall be packed symmetrically about the plane of the truss and as nearly parallel as practicable, but in no case shall the inclination of any bar to the plane of the truss exceed 1/16-inch per foot. They shall be packed as closely as practicable. They shall be held against lateral movement, and arranged so that adjacent bars in the same panel will not be in contact.

Gusset Plates.

141. The thickness of gusset plates connecting the chords and web

members of the truss shall be proportionate to the stress to be transferred, but shall not be less than ½-inch.

Facilities for Lifting Span.

142. Provision shall be made for lifting the span at the ends.

Masonry Plates.

143. Masonry plates shall not be less than one inch thick.

(10) Viaducts.

Type of Viaduct.

144. Viaducts shall consist usually of alternate tower spans and free spans of plate girders or riveted trusses supported on bents. The tower spans usually shall be not less than 30 feet long.

Bents and Towers.

145. Viaduct bents shall be composed preferably of two supporting columns, and the bents usually shall be united in pairs to form towers. Horizontal diagonal bracing shall be placed in all towers having more than two vertical panels at alternate intermediate panel points. In double track towers, provision shall be made for the transmission of the longitudinal force to both sides.

Single Bents.

146. Where long spans are supported on short single bents, such bents shall have hinged ends, or else have their columns and anchorages proportioned to resist the bending stresses produced by changes in temperature.

Bottom Struts.

147. The bottom struts of viaduct towers shall be proportioned for the calculated stresses, but in no case for less than one-fourth of the dead load reaction on one pedestal, considered as compressive stress. Provision shall be made in the column bearings for expansion of the tower bracing.

Batter.

148. The columns usually shall have a batter transversely of one horizontal to six vertical for single track viaducts, or one horizontal to eight vertical for double track viaducts.

Depth of Girders.

149. The depth of girders in viaducts preferably shall be uniform.

Spacing of Girders.

150. In single track viaducts, the girder spacing usually shall be uniform throughout, and shall be determined by the spacing for the longest span in the viaduct, according to the rules specified for deck plate girder spans.

151. In double track viaducts, the girders under each track usually shall be spaced 6 feet 6 inches between centers, and the inner lines

of girders shall be supported by cross-girders framed between and riveted to the posts.

Girder Connections and Bracing.

152. Girders of tower spans shall be fastened at each end to the tops of the posts or cross-girders. Girders between towers shall have one end riveted, and shall be provided with an effective expansion joint at the other end. No bracing or sway frame shall be common to abutting spans.

153. If neither of the girders under a track rests directly over a tower post, bracing shall be provided to carry the longitudinal force into the tower bracing without producing lateral bending stress in the cross-girders or posts.

Sole and Masonry Plates.

154. Sole and masonry plates shall be not less than ¾-inch thick.

Anchorage for Towers.

155. Anchor bolts for viaduct towers and similar structures shall be designed to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

(11) Materials.*

(a) STRUCTURAL AND RIVET STEEL.

Process.

156. Structural and rivet steel shall be made by the open-hearth process.

Properties.

157. Test specimens of structural and rivet steel shall (except as modified in Articles 160, 163 and 164) conform to the following requirements as to chemical and physical properties:

	Structural Steel	*Rivet Steel*
Phosphorus, maximum		
Acid	.06 per cent.	.04 per cent.
Basic	.04 per cent.	.04 per cent.
Sulphur, maximum	.05 per cent.	.045 per cent.
Tensile strength, pounds per square inch	55,000 to 65,000	46,000 to 56,000
Yield point, pounds per sq. in., minimum	30,000	25,000
Elongation in 8 in., minimum, per cent	$\frac{1500000}{\text{Tens. Str.}}$	$\frac{1500000}{\text{Tens. Str.}}$
Elongation in 2 in., minimum, per cent	22	

Ladle Analyses.

158. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phos-

---

*Specifications for materials conform to A. S. T. M. Standards. Serials A-7-16, A-27-16 and A-48-18 except as to the yield point requirements and Articles 178 and 179, and the footnote to Table II.

phorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the Engineer.

Check Analyses.

159. Analyses may be made by the Engineer from finished material representing each melt. The phosphorus and sulphur content thus determined shall not exceed that specified in Article 157 by more than 25 per cent.

Specimen Tension Tests of Eye-Bar Material.

160. In order to meet the minimum tensile strength of full size annealed eye-bars required in Article 284, the Contractor may determine the tensile strength to be obtained in specimen tests, the range not to exceed 14,000 lb. per sq. in. and the maximum not to exceed 74,000 lb. per sq. in. The material shall conform to the requirements as to physical properties other than that of tensile strength as specified in Articles 157, 163 and 166.

Yield Point.

161. The yield point shall be determined by the drop of the beam of the testing machine.

Speed of Testing Machine.

162. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but in no case shall the values given in the following table be exceeded:

Gage Length of Specimen	*Maximum Cross-head Speed (in. per minute) in Determining:*	
	Yield Point	*Tensile Strength*
2 in.	0.5	2.0
8 in.	2.0	6.0

Modifications in Elongation.

163. For structural steel over ¾-inch in thickness, a deduction of one from the percentage of elongation in 8 inches specified in Article 157 shall be made for each increase of ⅛-inch in thickness above ¾-inch, to a minimum of 18 per cent.

164. For structural steel under $\frac{5}{16}$-inch in thickness, a deduction of 2.5 from the percentage of elongation in 8 inches specified in Article 157 shall be made for each decrease of $\frac{1}{16}$-inch in thickness below $\frac{5}{16}$-inch.

Bend Tests.

165. The test specimens for plates, shapes, and bars (except as specified in Articles 166, 167 and 168) shall bend cold through 180 degrees without cracking on the outside of the bent portion, as follows:

(a) For material ¾-inch or less in thickness, flat on itself.

(b) For material more than ¾-inch to and including 1¼ inches in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(c) For material more than 1¼ inches in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

166. The test specimens for eye-bar flats shall bend cold through 180 degrees without cracking on the outside of the bent portion as follows:

(a) For material ¾-inch or less in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(b) For material more than ¾-inch to and including 1¼ inches in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

(c) For material more than 1¼ inches in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

167. The test specimens for pins, rollers and other bars, when prepared as specified in Article 173, shall bend cold through 180 degrees around a one-inch pin without cracking on the outside of the bent portion.

168. The test specimens for rivet steel shall bend cold through 180 degrees flat on themselves without cracking on the outside of the bent portion.

Test Specimens.

169. Tension and bend test specimens shall be taken from rolled steel in the condition in which it comes from the rolls, except as specified in Article 170.

170. Tension and bend test specimens for pins and rollers shall be taken from the finished bars after annealing when annealing is specified.

171. Tension and bend test specimens for plates, shapes and bars (except as specified in Articles 172, 173 and 174) shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 5, or with both edges parallel, except that bend test specimens for eye-bar flats may have three rolled sides.

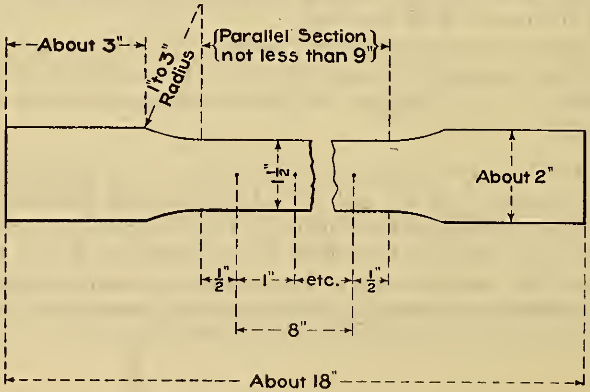


FIG. 5.

172. Tension and bend test specimens for plates and tension test specimens for eye-bar flats more than 1½ inches in thickness may be machined to a thickness or diameter of at least ¾-inch for a length of at least 9 inches.

173. Tension test specimens for pins, rollers, and bars (except eye-bar flats) over 1½ inches in thickness or diameter may conform to the dimensions shown in Fig. 6. In this case, the ends shall be of a form to fit the holders of the testing machine in such a way that the load will be axial. Bend test specimens may be 1 by ½-inch in section. The axis of the specimen shall be located at any point midway between the center and surface and shall be parallel with the axis of the bar.

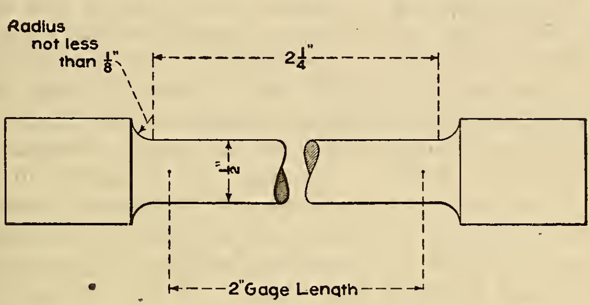


Fig. 6.

Note.—The gage length, parallel portions and fillets shall be as shown, but the ends may be of any form which will fit the holders of the testing machine.

174. Tension and bend test specimens for rivet steel shall be of the full-size section of the bars as rolled.

Number of Tests.

175. One tension and one bend test shall be made from each melt, except that if material from one melt differs ⅜-inch or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

176. If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

177. If the percentage of elongation of any tension test specimen is less than that specified in Article 157, and any part of the fracture is more than ¾-inch from the center of the gage length of a 2 inch specimen or is outside the middle third of the gage length of an 8 inch specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Character of Fracture.

178. Test specimens of structural or rivet steel shall show a fracture of uniform silky or bluish gray appearance, entirely free from visible slag inclusions or other foreign substances.

Surface Defects.

179. Finished rolled material shall be free from cracks, flaws, injurious seams, blisters, ragged and imperfect edges, and other surface defects. It shall have a smooth finish, and shall be straightened in the mill before shipment.

Permissible Variations in Weight and Thickness.

180. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent. from that specified, except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When ordered to weight per square foot, the weight of each lot in each shipment shall not vary from the weight ordered more than the amount given in Table I. The term "lot" as applied to Table I means all of the plates of each group width and group weight.

(b) When ordered to thickness, the thickness of each plate shall not vary more than 0.01 inch under that ordered. The overweight of each lot in each shipment shall not exceed the amount given in Table II. The term "lot" as applied to Table II means all of the plates of each group width and group thickness.

Marking.

181. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be separated properly and marked for identification. The identification marks shall be stamped legibly on the end of each pin and roller. The melt number shall be marked legibly by stamping if practicable, on each test specimen.

(b) CAST STEEL.

Process.

182. Cast steel shall be made by the open-hearth or the crucible process.

Heat Treatment.

183. Castings shall be annealed.

Chemical and Physical Properties.

184. Test specimens of cast steel shall conform to the following requirements as to chemical composition and tensile properties:

Elements Considered		*Min. Ten. Strength lb. per sq. in.*	*Min. Yield Point lb. per sq. in.*	*Min. Elongation in 2 in.*	*Min. Reduction of Area*
Phosphorus not over	0.05%	60,000	30,000	22%	30%
Sulphur not over	0.05%				

TABLE I.—PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT.

ORDERED WEIGHT, Llb. Per Sq. Ft.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS																	
	Under 48 In.		48 to 60 In., Excl.		60 to 72 In., Excl.		72 to 84 In., Excl.		84 to 96 In., Excl.		96 to 108 In., Excl.		108 to 120 In., Excl.		120 to 132 In., Excl.		132 in. or Over.	
	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.
Under 5..........	5	3	5.5	3	6	3	7	3	....	....	....	....	....	....	....	....	....	....
5 to 7.5, excl...	4.5	3	5	3	5.5	3	6	3	....	....	....	....	....	....	....	....	....	....
7.5 to 10 excl....	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	....	....	....	....
10 to 12.5, excl...	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3
12.5 to 15, excl...	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3
15 to 17.5, excl...	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3
17.5 to 20, excl...	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3
20 to 25, excl...	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3
25 to 30, excl...	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3
30 to 40, excl...	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3
40 or over.........	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1⅓ times the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

ORDERED THICKNESS, Inches.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHTS.								
	Under 48 In.	48 to 60 In., Excl.	60 to 72 In., Excl.	72 to 84 In., Excl.	84 to 96 In., Excl.	96 to 108 In., Excl.	108 to 120 In., Excl.	120 to 132 In., Excl.	132 In. or Over.
Under ⅛...........	9	10	12	14	....	....	....	....	....
⅛ to 3/16, excl........	8	9	10	12	....	....	....	....	....
3/16 to ¼, excl........	7	8	9	10	12	....	....	....	....
¼ to 5/16, excl........	6	7	8	9	10	12	14	16	19
5/16 to ⅜, excl........	5	6	7	8	9	10	12	14	17
⅜ to 7/16, excl........	4.5	5	6	7	8	9	10	12	15
7/16 to ½, excl........	4	4.5	5	6	7	8	9	10	13
½ to ⅝, excl........	3.5	4	4.5	5	6	7	8	9	11
⅝ to ¾, excl........	3	3.5	4	4.5	5	6	7	8	9
¾ to 1..............	2.5	3	3.5	4	4.5	5	6	7	8
1 or over............	2.5	2.5	3	3.5	4	4.5	5	6	7

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than 1½ times the amount given in this table.

Ladle Analyses.

185. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least ¼-inch beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the Engineer.

Check Analyses.

186. Check analyses may be made by the Engineer from a broken tension or bend test specimen. The phosphorus and sulphur content thus determined shall not exceed that specified in Article 184 by more than 20 per cent. Drillings for analysis shall be taken not less than ¼-inch beneath the surface.

Yield Point.

187. The yield point shall be determined by the drop of the beam of the testing machine. The speed of the machine shall conform to the requirements of Article 162.

Bend Test.

188. The test specimen shall bend cold through 120 degrees around a one inch pin without cracking on the outside of the bent portion.

Test Specimens.

189. Sufficient test bars from which the test specimens required by Article 192 may be selected, shall be attached to castings weighing 500 lb. or more, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt. Test bars shall be annealed with the castings they represent.

190. Tension test specimens shall conform to the dimensions shown in Fig. 6.

191. Bend test specimens shall be machined to 1 inch by ½-inch in section with corners rounded to a radius not over 1/16-inch.

Number of Tests.

192. One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in the annealing charge, one tension and one bend test shall be made from each melt.

193. If the percentage of elongation of any tension test specimen is less than that specified in Article 184 and any part of the fracture is more than ¾-inch from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

194. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot not more than twice and retests shall be made as specified in Article 184.

Workmanship and Finish at Foundry.

195. The castings shall conform substantially to the drawings and shall be made in a workmanlike manner. The castings shall be free from injurious defects.

Inspection at Foundry.

196. Tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

197. Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

(c) CAST IRON.

Process.

198. Cast iron shall be of tough grey iron, and shall be made by the cupola process.

Finish.

199. Castings shall be true to pattern and free from excessive shrinkage. They shall be free from cracks, cold shuts, blow holes and other flaws.

Chemical Composition.

200. The sulphur content of cast iron shall not exceed the following:

Light castings	0.10 per cent.
Medium castings	0.10 per cent.
Heavy castings	0.12 per cent.

Drillings taken from the fractured ends of the transverse test bars shall be used for the sulphur determinations. One determination shall be made from each set of bars.

Classification.

201. Castings shall be classified as light, medium and heavy.

- (a) Light castings are those having any section less than ½-inch thick.
- (b) Heavy castings are those having no section less than two inches thick.
- (c) Medium castings are those not included in either of the two classes above.

Test Bar.

202. Tests shall be made on the "Arbitration Test Bar" of the American Society for Testing Materials, as shown by Fig. 1, Serial A48-18.

Tension Tests.

203. Tension tests will be made only when specified by the Engineer and at the expense of the Company.

Number of Tests.

204. Two sets of two test bars each shall be cast from each melt in thoroughly dried green sand moulds, one set from the first iron poured and the other set from the last iron poured. Where the melt exceeds 20 tons, an additional set of two bars shall be cast from each additional 20 tons or fraction thereof.

Transverse Tests.

205. A transverse test of each bar cast shall be made. The load shall be applied at the middle, and the supports shall be spaced 12 inches apart. The load on the test bar at rupture shall be not less than the following:

Light castings	2500 pounds
Medium castings	2900 pounds
Heavy castings	3300 pounds

The deflection at rupture shall in no case be less than 0.10-inch. The rate of application of the load shall be such that a central deflection of 0.10-in. is produced in from 20 to 40 seconds.

(12) Workmanship.

Class of Work.

206. The work shall be "Punched Work" or "Reamed Work" as stipulated.

General.

207. The workmanship and finish shall be equal to the best general practice in modern bridge shops. Material at the shops shall be kept clean and protected from the weather as far as practicable.

Straightening Material.

208. Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks and bends may be cause for rejection.

Finish.

209. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

Punched Work.

210. In punched work, holes in material whose thickness is not greater than the diameter of the rivets plus ⅛-inch, may be punched full size. Holes in material of greater thickness shall be drilled.

Reamed Work.

211. In reamed work, holes in material ⅞-inch thick and less, used for lateral, longitudinal and sway bracing, lacing, stay plates and diaphragms, may be punched full size.

212. Holes in other material ¾-inch thick and less, shall be sub-punched and reamed.

213. Holes in material more than ¾-inch thick shall be drilled.

Punched Holes.

214. Full size punched holes shall be $\frac{1}{16}$-inch larger than the nominal diameter of the rivets. The diameter of the die shall not exceed the diameter of the punch by more than $\frac{3}{32}$-inch. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes may be cause for rejection.

Sub-Punched and Reamed Holes.

215. In sub-punched and reamed work, the holes shall be punched $\frac{3}{16}$-inch smaller and, after assembling, reamed $\frac{1}{16}$-inch larger than the nominal diameter of the rivet. The diameter of the punch used shall be $\frac{3}{16}$-inch smaller than the nominal diameter of the rivet and the diameter of the die not more than $\frac{3}{32}$-inch larger than the diameter of the punch. Outside burrs shall be removed with a tool making a $\frac{1}{16}$-inch fillet.

Accuracy of Punching in Reamed Work.

216. In sub-punched and reamed work, the punching shall be so accurately done that, after assembling and before reaming, a cylindrical pin ⅛-inch smaller in diameter than the nominal size of the punched hole may be entered, perpendicular to the face of the member, without drifting, in at least 75 of any group of 100 contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If any hole will not pass a pin $\frac{3}{16}$-inch smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection.

Reaming After Assembling.

217. Reaming shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Before riveting, they shall be taken apart, if necessary, and any shavings removed. When it is necessary to take the members apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted.

Accuracy of Reaming and Drilling.

218. When holes are reamed or drilled, 85 of any group of 100 contiguous holes in the same plane shall, after reaming or drilling, show no offset greater than $\frac{1}{32}$-inch between adjacent thicknesses of metal.

Reamed Holes.

219. Reamed holes shall be cylindrical, perpendicular to the member, and not more than $\frac{3}{32}$-inch larger than the nominal diameter of the rivets. Reamers preferably shall not be directed by hand. Outside burrs shall be removed with a tool making a $\frac{1}{16}$-inch fillet.

Drilled Holes.

220. Drilled holes shall be $\frac{1}{16}$-inch larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed.

Assembling for Drilling.

221. Connecting parts requiring drilled holes shall be assembled and securely held together while being drilled.

Shop Assembling.

222. The parts of riveted members shall be well pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. Surfaces in contact shall be painted. Bolts in field connection holes shall be left in place.

Field Connections.

223. Solid floor sections shall be assembled to the girders or trusses, or to suitable frames, in the shop, and the end connections made to fit. (103)

224. In reamed work, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template.

225. In punched work, the field connections (except those in lateral, longitudinal and sway bracing) shall be reamed to metal templates.

Match-Marking.

226. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the Engineer.

Rivets.

227. The size of rivets called for on the plans shall be the size of the rivet before heating.

228. Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

Riveting.

229. Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and carbon deposit. When driven, they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the

adjacent metal, and, if necessary, they shall be drilled out. Caulking or re-cupping will not be permitted.

230. Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

231. When necessary to drive rivets with a pneumatic riveting hammer, a pneumatic bucker shall be used for holding up, when practicable.

Field Rivets.

232. Field rivets shall be furnished in excess of the nominal number required to the amount of 15 per cent. plus ten rivets, for each size and length.

233. Field rivets shall be carefully selected, and shall be free from fins on the under side of the head.

Turned Bolts.

234. Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit with the threads entirely outside of the holes. A washer not less than ¼-inch thick shall be used under each nut.

Planing Sheared Edges.

235. Sheared edges of material more than ⅝-inch in thickness and carrying calculated stress shall be planed to a depth of ¼-inch. Re-entrant cuts shall be filleted before cutting.

Lacing Bars.

236. The ends of lacing bars shall be neatly rounded, unless otherwise called for.

Fit of Stiffeners.

237. Stiffeners under the top flanges of deck girders and at all bearing points shall be milled or ground to bear against the flange angles. Other stiffeners must fit sufficiently tight against the flange angles to exclude water after being painted. Fillers and splice plates shall fit within ¼-inch at each end.

Web Plates.

238. Web plates of girders which have no cover plates may be ⅛-inch above or below the backs of the top flange angles. Web plates of girders which have cover plates may be ½-inch less in width than the distance back to back of flange angles.

239. When web plates are spliced, not more than ⅜-inch clearance between ends of plates will be allowed.

Facing Floor Beams, Stringers and Girders.

240. Floor beams, stringers and girders having end connection angles shall be made of exact length after the connection angles are riveted. If facing is necessary, the thickness of the angles shall not be reduced more than ⅛-inch at any point.

Finished Members.

241. Finished members shall be true to line and free from twists, bends and open joints.

Abutting Joints.

242. Abutting joints in compression members and girder flanges, and, where so specified on the drawings, in tension members shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed ¼-inch.

Eye-Bars.

243. Eye-bars shall be straight, true to size, and free from twists, folds in the neck or head, and other defects. The heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the Engineer. The thickness of the head and neck shall not overrun more than $\frac{1}{16}$-inch for bars 8 inches or less in width, ⅛-inch for bars more than 8 inches and not more than 12 inches in width, and $\frac{3}{16}$-inch for bars more than 12 inches wide.

244. Eye-bars which are to be placed side by side in the structure shall be bored so accurately that, upon being placed together, the pins will pass through the holes at both ends at the same time without driving. Eye-bars shall have both ends bored at the same time.

Annealing.

245. Eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling. Proper instruments shall be provided for determining at all times the temperature of the bars.

246. Other steel which has been partially heated shall be properly annealed except where used in minor parts.

Boring Pin Holes.

247. Pin holes shall be bored true to gage, smooth, straight, at right angles with the axis of the member and parallel with each other, unless otherwise required. The variation from the specified distance from outside to outside of pin holes in tension members, or from inside to inside of pin holes in compression members, shall not exceed $\frac{1}{32}$-inch. In built-up members the boring shall be done after the member is riveted.

Boring Pins.

248. Pins larger than 9 inches in diameter shall have a hole bored longitudinally through the center of each not less than 2 inches in diameter.

Pin Clearances.

249. The difference in diameter between the pin and the pin hole shall be 1/50-inch for pins up to 5 inches in diameter, and $\frac{1}{32}$-inch for larger pins.

Pins and Rollers.

250. Pins and rollers shall be accurately turned to gage and shall be straight, smooth and free from flaws.

Screw Threads.

251. Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than 1⅜ inches, they shall be made with six threads to an inch.

Welds.

252. Welds in steel will not be allowed, except to remedy minor defects.

Forging Pins.

253. Pins larger than 7 inches in diameter shall be forged and annealed.

Bearing Surfaces Planed.

254. The top and the bottom surfaces of base and cap plates of columns and pedestals, except those in contact with masonry, shall be planed, or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced.

255. Sole plates of plate girders shall have full contact with the girder flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on the surfaces in contact with steel and shall have the bottom surfaces resting on masonry rough finished.

Pilot Nuts.

256. Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

(13) Weighing and Shipping.

Weight Paid for.

257. The payment for pound price contracts shall be based on the scale weight of the metal in the fabricated structure, including field rivets shipped. The weight of the field paint and cement, if furnished, boxes and barrels used for packing, and material used for staying or supporting members on cars, shall be excluded.

Variation in Weight.

258. If the weight of any member is more than 2½ per cent. less than the computed weight, it may be cause for rejection.

259. The greatest allowable variation of the total scale weight of any structure from the weights computed from the approved shop drawings shall be 1½ per cent. Any weight in excess of 1½ per cent. above the computed weight shall not be paid for by the Company.

Computed Weight.

260. The weight of steel shall be assumed at 0.2833 lb. per cubic inch.

261. The weights of rolled shapes, and of plates, up to and including 36 inches in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts and open holes.

262. The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in Article 180.

263. The weight of heads of shop driven rivets shall be included in the computed weight.

264. The weights of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 per cent. for fillets and overrun.

Weighing of Members.

265. Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall furnish satisfactory scales and do the handling of the material for weighing.

Marking and Shipping.

266. Members weighing more than 5 tons shall have the weight marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, other small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each package, box or crate.

267. Long girders shall be so loaded and marked that they may arrive at the bridge site in position for erection without turning.

268. Anchor bolts, washers and other anchorage or grillage materials shall be shipped in time for them to be built into the masonry.

(14) Shop Painting.

Shop Cleaning and Painting.

269. Unless otherwise specified, steel work, after it has been accepted by the Inspector and before leaving the shop, shall be thoroughly cleaned and given one coat of approved paint, applied in a workmanlike manner and well worked into joints and open spaces. Cleaning shall be done with steel brushes, hammers, scrapers and chisels, or by other equally effective means. Oil, paraffin and grease shall be removed by wiping with benzine or gasoline. Loose dirt shall be brushed off with a dry bristle brush before the paint is applied.

Surfaces in Contact.

270. Surfaces coming in contact shall be cleaned and given one coat of paint on each surface before assembling.

Erection Marks.

271. Erection marks shall be painted on painted surfaces.

Painting in Damp or Freezing Weather.

272. Painting shall not be done in damp or freezing weather except under cover, and the steel must be free from moisture or frost when the paint is applied. Material painted under cover in damp or freezing weather shall be kept under cover until the paint is dry.

Mixing of Paint.

273. Paint shall be thoroughly mixed before applying, and the pigments shall be kept in suspension.

Machine Finished Surfaces.

274. Machine finished surfaces of steel (except abutting joints and base plates) shall be coated with white lead and tallow, applied hot as soon as the surfaces are finished and accepted by the Inspector.

(15) Mill and Shop Inspection.

Facilities for Inspection.

275. Facilities for inspection of material and workmanship in the mill and shop shall be furnished by the Contractor to the Inspectors, and the Inspectors shall be allowed free access to the necessary parts of the premises.

Mill Orders and Shipping Statements.

276. The Contractor shall furnish the Engineer with as many copies of material orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown.

Notice of Rolling.

277. The Contractor shall give ample notice to the Engineer of the beginning of rolling at the mill, and of work at the shop, so that inspection may be provided. No material shall be rolled nor work done before the Engineer has been notified where the orders have been placed.

Cost of Testing.

278. The Contractor shall furnish, without charge, test specimens, as specified herein, and all labor, testing machines and tools necessary to make the specimen and full size tests.

Inspector's Authority.

279. The Inspector shall have the power to reject materials or workmanship which do not come up to the requirements of these specifications; but in cases of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

Rejections.

280. The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective.

281. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

(16) Full-Size Tests.

Full-Size Tests of Eye-Bars.

282. The number and size of the bars to be tested shall be stipulated by the Engineer before the mill order is placed. The number shall not exceed 5 per cent. of the whole number of bars ordered, with a minimum of two bars on small orders.

283. The test bars shall be of the same section as the bars to be used in the structure and of the same length if within the capacity of the testing machine. They shall be selected by the Inspector from the finished bars preferably after annealing. Test bars representing bars too long for the testing machine shall be selected from the full length bar material after the heads on one end have been formed and shall have the second head formed upon them after being cut to the greatest length which can be tested.

284. Full-size tests of eye-bars shall show a yield point of not less than 29,000 pounds per square inch, an ultimate strength of not less than 54,000 pounds per square inch, and an elongation of not less than 10 per cent. in a length of 20 feet measured in the body of the bar. The fracture shall show a silky or finely granular structure throughout.

285. If a bar fails to meet the requirements of Article 284, two additional bars of the same size and from the same mill heat shall be tested. If the failure of the first test bar is on account of the character of the fracture only, the bars represented by the test may be reannealed before the additional bars are tested.

286. If two of the three bars tested fail, the bars of that size and mill heat shall be rejected.

287. A failure in the head of a bar shall not be cause for rejection if the other requirements are fulfilled.

288. A record of the annealing charges shall be furnished the Engineer showing the bars included in each charge and the treatment they receive.

289. Bars thus tested which meet the requirements of the specifications shall be paid for by the Company at the same unit prices as the structures. Bars which fail to meet the requirements of the specifications, and all bars rejected as a result of tests, shall be at the Contractor's expense.

Index to Steel Bridge Specifications.

Articles

Abutting joints 74, 75, 242
Accessibility of parts........... 52
Access to premises............. 275
Accuracy of punching in reamed work 216
Accuracy of reaming and drilling 218
Ambiguity of stress............. 16
Analyses—check 159, 186
" —ladle 158, 185
Anchorage for towers........... 155
Anchorages in viaducts......... 146
Anchor bolt holes............... 135
Anchor bolts 135, 155
" " —shipment 268
Angles—effective area of........ 55
" —end connection 101, 103
" in compression — outstanding legs of 66
Angles in tension—effective area of 55
Angles—minimum, in bracing... 113
Angles—sizes of rivets in....... 62
Angles—stiffening, on gussets and knee-braces 129, 130
Annealing 170, 183, 245, 246, 253
" charges, record of.......... 288
" —of eye-bars 245
" —of test specimens........ 170
Approval—material ordered prior to 7
Approval of shop drawings.....5, 6
Area of angles—effective....... 55
Area of flange—proportioning.48, 117
Assembling for drilling.......... 221
Assembling in shop............. 222
Assembling—reaming after 217
Assembling riveted trusses..... 224
Assembling skew portals....... 224
Assembling solid floor sections.. 223
Authority of inspector.......... 279
Ballast—depth 19
Ballasted floor bridges—distribution of load............... 27
Ballast—weight of 19
Bars, lacing—angle of.......... 73
" " —ends rounded 236
Base plates—planing of......... 254
Batter of viaduct columns...... 148
Bearing area—effective 41
Bearing area—end stiffeners ... 124
Bearing area—pins, bolts, rivets 41
Bearing on masonry 133, 134
Bearing plates, continuous 99

Articles

Bearings 8
" —expansion 89
" —fixed 90
" —inclined 93
Bearing surfaces planed.....254, 255
Bearing—unit stresses in........ 38
Bend tests.......165 to 168 incl. 188
" " —specimens for......169 to 174 incl., 191
Bents and towers in viaducts.. ....144, 145, 146
Bents—single, in viaducts....... 146
Bolts, anchor 135, 155, 268
Bolts—bearing area 41
Bolts in place of rivets......... 234
Bolts—turned 38, 85, 234
Boring pin holes..............244, 247
Boring pins 248
Bottom chord—stiffened......... 138
Bottom lateral bracing in deck girders 107
Bottom struts of towers........ 147
Bracing..49, 66, 105 to 114, incl., 145, 152, 153, 211
" —bottom lateral 107
" —design of 105, 106
" —double system 106, 113
" —girders of tower spans... 152
" —intersections of 113
" —lateral, proportioning of. 35
" —minimum angles 113
" —portal 110
" —sway 109, 111
" —to be stiff................ 105
" —top lateral 108, 111
" —tower 145, 153
Brand of manufacturer.......... 181
Bridges—types of 9
Burrs—removal of 215, 219, 220
Calculations—dimensions for ... 11
Camber 137
Cap plates—planing of.......... 254
Castings—computed weight...... 264
" —iron, classification of. 201
Cast iron ....8, 198 to 205 incl.
" " —chemical composition 200
" " —tension test 203
" " —test bar 202
" " —transverse test 205
" " —where used 8
Cast pedestals 255
Cast steel ....8, 182 to 197 incl.
" " —analyses 185, 186
" " —annealed 183
" " —bend test 188

Articles
Cast steel — chemical requirements 184
" " —tensile properties .. 184
" " —test specimens 173, 189, 190, 191
" " —unit stresses in..... 39
" " —where used 8
Castings—iron, classification of. 201
Causes for rejection........... ....208, 214, 216, 229, 258, 279, 286
Centrifugal force 17, 36
Changes in approved drawings 5
Character of fracture.......178, 284
Check analyses 159, 186
Chemical requirements..157, 184, 200
Chipping 209
Class of work required.......... 206
Classification of iron castings... 201
Cleaning before painting........ 269
Clearance for lateral bracing.... 114
Clearances 13
" on curves 13
" —pin 249
Closed sections 52
Columns—facing ends 254
Columns—viaduct, batter 148
Combination of stresses 18, 47
Combined stresses 45, 46
Company defined 1
Compression flanges 48
Compression members 65
Compression members — forked ends of 82
Compression members—length.. 49
Compression members — pin plates 79
Compression members—pitch of rivets at ends............... 64
Compression members—section.. 65
Compression members—splices 74, 75
Compression members — stay plates and lacing...67 to 71, incl.
Compression—unit stress 38
Computed weight....260 to 264, incl.
Concentrated loading—stiffeners at points of 127
Concrete—weight of 19
Connection angles—riveting to columns before planing...... 254
Connection angles—size of...101, 103
" " —stringer..101, 240
Connections—eccentric 54
" —field 223, 224, 225
" —floor beam 100, 240
" —girder, in viaducts........ 152
" —reversal of stress......... 44
" —solid floor 103, 223
" —symmetrical 57
" —strength of 57
Continuous members 45
Contractor defined 1

Articles
Contractor's responsibility for drawings 6
Corrosion—metal subject to..... 58
Cost of testing 278
Counters 56
Countersunk rivets — allowance for 38, 41
Cover plates—length of.......... 119
" " —proportion of flange area 117
" " —thickness of 65, 118
Crimping of stiffeners........124, 127
Cross-frames, girder 112
" " between stringers.. 102
Cross-girders 151, 153
Cross ties 95
Curved ends on through girders. 131
Curves—clearance on 13
" —deck spans on.......... 14
" —eccentricity of load on. 31
" —superelevation on 13
Dead load 17, 19, 43
Deck girders, shipped riveted... 132
Deck spans on curves........... 14
Defects—surface 179
Definitions of terms............. 1
Depth for calculation........... 11
Depth of girders in viaducts... 149
Depth ratios 51
Design—details of......49 to 94, incl.
Design—general features of.... ....8 to 16 incl.
Design of bracing............105, 106
" " plate girders 116
Details of design.......49 to 94, incl.
Devices—patented 4
Diagonal tension in webs....... 40
Diameter of rivets—effective.... 42
Diaphragms 99, 211
Differences between drawings and specifications 3
Dimensions for calculation...... 11
Double webs—pitch of rivets in. 60
Drain holes 53
Drawings required for approval 5
Drawings and specifications, differences 3
Drawings—changes in 5
" —contractor's responsibility for 6
" —material ordered prior to approval of 7
" —proposals and ...1 to 7, incl.
" to govern 3
Drifting 222
Drilled holes 210, 213, 220
Drilling—accuracy of 218
" —assembling for 221
Drilling through assembled parts 224
Driving nuts 256

Articles
Dynamic effect of live load...... 17
Dynamic increment 28
Eccentric connections 54
Eccentricity of load on curves.. 31
Edge distance 61
Edges—planed 235
Effective area of angles......... 55
Effective bearing area........... 41
Effective diameter of rivets..... 42
Electric traction—impact for.... 29
Elongation—modifications in..163, 164
End bearings on masonry...133, 134
End connection angles.......101, 103
End posts 136
End posts—bracing 109
Ends of through girders........ 131
End stiffeners 99, 124
Engineer defined 1
Erection marks 271
Expansion 88, 147
" bearings 89
" joints in tower spans...... 152
" rollers 91
Eye-bar heads—form of......... 243
Eye-bar heads—method of manufacture 243
Eye-bar material—specimen tension tests of 160
Eye-bars 139, 243, 244, 245
" —accuracy of boring....... 244
" —annealing 245
" —character of fracture.... 284
" —expense of testing....... 289
" —failure in the head....... 287
" —finish of 243
" —form of head............. 243
" —full size tests.282 to 289, incl.
" —packing 140
" —physical requirements.... 284
" —record of annealing charges 288
" —rejection 286
" —retest 285
" —section through pin hole. 139
" —selection of test bars.... 283
" —size of pin.............. 139
" —size of test bars......... 283
" —thickness of 139
Facilities for inspection......... 275
Facilities for lifting span...... 142
Facing of abutting joints....... 242
" of columns 254
" floor beams, stringers and girders 240
Features of design—general....
.....................8 to 16 incl.
Field connections 223, 224, 225
Field connections — responsibility for 6
Field connections—reaming...... 225
Field rivets 232, 233
" " —allowance for 38

Articles
Field rivets—excess 232
" " —selection of 233
Fillers 81
" —fit of 237
Finish of iron castings.......... 199
" of pins and rollers......... 250
" required 209, 241, 250
" of steel castings............ 195
Finished members—straight..... 241
Finished surfaces—protection of 274
Finish of ends of girders....131, 240
Fit of stiffeners................. 237
Fixed bearings 90
Flange angles—facing abutting joints 242
" " —proportion of flange area 117
Flange area—proportioning...... 117
Flange plates—length of........ 119
" " —proportion of flange area 117
" " —thickness of 118
Flange rivets, girder........... 121
Flange sections of girders......
.....................117, 118, 119
Flange splices 122
Floor-beam connections 100, 240
" connections—solid 103
" —depth of 11
" —facing of 240
" members 96, 97
" sections—assembling 222
" —spacing of 12
" —span length 11
" —timber, design of......... 24
" —weight of 19
Floors.15, 24, 25, 26, 27, 95 to 104 incl.
" —ballasted—live load 27
Floors in skew bridges......... 15
" —solid, proportioning of.. 104
" —steel, proportioning of 25, 26
" —types of 95
Force—centrifugal 26
" —lateral..........32 to 35, incl.
" —longitudinal 37
Forging of pins................. 253
Forked ends 82, 83, 84
Fracture—character of.......178, 284
Frames—stringer 102
Free spans in viaducts......... 144
Full-size tests of eye-bars.....
...................282 to 289 incl.
Gearing of rollers.............. 91
General features of design.....
.....................8 to 16 incl.
General—workmanship 207
Girder connections and bracing in viaducts 152, 153
Girders—bearing on masonry 133, 134
" —depth of 11, 51
" —depth of in viaducts..... 149
" —facing of 240

Articles
Girders—I-beam 51, 99
" —in viaducts, connections and bracing 152, 153
" —long, shipment of....... 267
" —plate ....115 to 135, incl.
" —spacing of....12, 115, 150, 151
Grillage 268
Grip of rivets................... 63
Gusset plates in trusses........ 141
Gusset plates in through girders 129, 130
Hand driven rivets—allowance for 38
Heat treatment of cast steel... 183
Hip verticals—stiffened 138
Holes—drilled 210, 213
Holes for anchor bolts.......... 135
" —punched 210, 211, 214
" slotted for expansion...... 135
" sub-punched and reamed.. .... 212, 215, 216
Horizontal bracing in towers.... 145
" shear 121
I-beam girders 99
Impact 17, 24, 28, 29, 30
" formula 28
" for electric traction........ 29
Inclined bearings 93
" end posts 136
Indirect splices 80
Individual members—weights of 266, 276
Inertia—moment of—design of plate girders by............ 116
Inertia—moment of—design of solid floors by.............. 104
Inspection of steel castings..... 196
Inspection—facilities for 275
Inspection—mill and shop...... ....275 to 281, incl.
Inspector defined 1
Inspector's authority 279
Intermediate stiffeners ....125 to 128, incl.
Interpretation of drawings...... 3
Invitations to bidders........... 2
Iron—cast..........8, 198 to 205, incl.
Jaws 82
Joints 74, 75
" —abutting 242
Knee braces in through girders 129, 130
Lacing ....69 to 73, incl., 211
Lacing bars—angle of 73
" " —connections of ... 72
" " —ends rounded...... 236
" " —minimum width... 69
" " —rivets in 72, 73
" " —shear in 69, 70
" " —spacing of 71
" " —thickness 69
Ladle analyses 158, 185

Articles
Lateral angles 113
Lateral bracing.....107, 108, 111, 113
" " clearance for 114
" " proportioning of.. 35
Lateral connections 105
" forces 32, 33, 34, 35
" loads 17, 30
Length of span, defined......... 11
Lifting, facilities for............ 142
Lighter loading permitted....... 21
Limiting lengths of members..49, 50
Limiting thickness of metal..... 58
Live load ....
....17, 20, 21, 22, 23, 25, 26, 27, 34
" " —distribution of.24, 27, 121
" " on solid floors....25, 26, 27
Loading—concentrated, stiffeners at points of............. 127
Loading of long girders......... 267
Load on curves—eccentricity of. 31
Loads ....17 to 37, incl.
" —live ....
17, 20, 21, 22, 23, 25, 26, 27, 34
Long girders—loading of........ 267
Longitudinal forces 17, 30, 37
" " —in tower spans 153
Long rivets 63
Loose rivets—removal of........ 229
Lug angles 55
Machine-finished surfaces 274
Marking of mill material........ 181
" and shipping 266, 267, 268
" diagram for erection....... 226
Masonry bearings for girders 133, 134
" plates 143, 154
" " —planing 255
Match marks 217, 226
Material ordered prior to approval 7
Material—protection of 207
Materials ....156 to 205, incl.
Material—straightened at mill.. 179
" —straightening at shop.... 208
Materials—used 8
Melt numbers 181
Members—compression 65
" —limiting lengths of.....49, 50
" —pin connected 84
" —riveted in pin connected trusses 138
" —sections of, truss........ 136
" —weighing of 265
Metal templates 224, 225
Mill and shop inspection....... ....275 to 281, incl.
Mill orders and shipping statements 276
Mixing of paint................. 273
Modifications in elongation..163, 164
Moment of inertia—design of plate girders by............. 116

Articles
Moment of intertia—design of solid floors by.............. 104
Moment—splicing for 123
Multiple tracks 23
Name plates 94
Net section—at pin hole......... 76
" " defined 77, 78
" " —of flange splices.... 122
" " —of riveted members. 77
Notice of rolling................ 277
Number of tests................ ...175, 176, 177, 192, 193, 194, 204
Number of trusses.............. 10
Nuts—driving and pilot......... 256
" —pin 83, 251
" —sleeve 87
" —standard 251
Outstanding legs of angles in compression 66
Packing eye-bars 140
Packing for shipment........... 266
Painting—erection marks 271
" —in damp or freezing weather 272
" —shop ....269 to 274, incl.
" —surfaces in contact...222, 270
Paint—mixing of 273
" —shop coat 269
Panel lengths 12
Parties to contract............ 1
Parts accessible 52
Patented devices 4
Pedestals, girder 133
" and shoes 92, 254, 255
Permissible variations in weight and thickness 180
Physical requirements—cast iron 205
Physical requirements—steel.157, 184
Pilot nuts 256
Pin clearances 249
Pin-connected members 84
" " trusses—riveted members in 138
" " trusses—where used.. 9
Pin-holes—boring 244, 247
" " —clearance 249
" " —net section at......76, 139
" " —reinforcing 79
Pin-nuts 83, 251
Pin-plates 79
" " —rivets in 79
Pins 83
" —annealing 253
" —bearing area 41
" —bored 83, 248
" —boring of 248
" —diameter of, in eye-bars. 139
" —finish of 250
" —forging of 253
Pitch of rivets................. 60
" " " at ends 64
Planing abutting joints......... 242

Articles
Planing base and cap plates.... 254
Planing bearing surfaces....254, 255
Planing pedestals 254, 255
Planing sheared edges 235
Planing sole and masonry plates 255
Plans 2, 3, 5, 6, 7
Plate girders.........115 to 135 incl.
" " —anchor bolts......... 135
" " —bearing on masonry 38, 133
" " —cross-frames 112
" " —deflection 51
" " —depth of 11, 51
" " —design of 116
" " —filler plates 237
" " —finish of ends of.... 131
" " —flange rivets 121
" " —flange sections....... ....117, 118, 119
" " —gusset plates 129
" " —knee-braces 129, 130
" " —lateral bracing ..107, 108
" " —length of flange plates.............. 119
" " —masonry plates 255
" " —shipment 132, 267
" " —sole plates 134, 255
" " —spacing of deck..... 115
" " —splices ..122, 123, 237, 242
" " —stiffeners ....124 to 128, incl., 237
" " —thickness of web plates 120, 238, 239
" " —web plates 238, 239
" " —where used 9
Plates—base and cap............ 254
" —end, on through girders.. 131
" —girder filler 237
" —girder splice 123, 237
" —girder web 120, 138, 239
" —gusset 129, 141
" —masonry 143, 154, 255
" —name 94
" —permissible variations.180, 262
" —pin 79
" —side flange 117
" —sole 134, 154, 255
" —stay 67, 68
" —weight of 261, 262
Pneumatic riveters 231
Pockets 53
Points of concentrated loading.. 127
Portal and sway bracing.109, 110, 111
Portal bracing 110
Power riveters 230
Process of manufacture—cast iron 198
Process of manufacture—cast steel 182
Process of manufacture structural and rivet steel......... 156
Properties of cast steel......... 184
" of full size eye-bars........ 284

Articles
Properties of structural and rivet steel 157
Proportioning of parts..38 to 48 incl.
Proportioning of lacing bars...69, 70
Proportioning solid floors 104
" web members 43
Proposals 2
" and drawings ......1 to 7 incl.
Protection of material 207
Punched holes 214, 215
" work 206, 210
Punching 210, 211, 212
" —accuracy of, in reamed work 216
Rail—height of 13
Rails and fastenings—weight of 19
Reamed holes 215, 219
" " for bolts 234
Reamed work 206, 211, 212, 213
Reamed work — accuracy of punching 216
Reaming 212, 215, 217, 218, 234
" after assembling 217
" —accuracy of 218
" to metal template.......224, 225
Record of annealing charges.... 288
Re-entrant cuts 235
Reinforcing plates 79
Rejected material to be replaced 281
Rejection—causes for 197, 208, 214, 216, 229, 258, 279, 286
" after acceptance 280
" —authority for 279
Rejection of punched work and of punched and reamed work 214, 216
Removal of burrs........215, 219, 220
Replacement after rejection..... 281
Resultant stress 44
Retest 177, 194
Reversal of stress............... 44
Riveted members in pin-connected trusses 138
Riveted members—net section.. 77
Riveted trusses—assembling..... 224
" " —where used..... 9
Rivet heads 228
" " —computed weight.. 263
Riveting 229, 230, 231
Rivets 227, 228
" —bearing area 41
" —condition when driven... 229
" —connecting flanges to web plates 121
" —diameter of 59, 62
" —direct load on............ 121
" —driving by power........ 230
" —edge distance 61
" —effective diameter 42
" —excess in indirect splices 80
" —field 232, 233
" —field and countersunk—allowance for 38, 41

Articles
Rivets—grip of 63
" —in end stiffeners......... 124
" —in lacing bars..........72, 73
" —in pin plates............ 79
" —in web splices........... 123
" —long 63
" —loose—removal of 229
" —pitch 60
" —pitch at ends of compression members 64
" —sizes of 59, 227
" —stitch, pitch of.......... 60
Rivet steel, 156, 157, 158, 159, 161, 162, 168, 174, 175, 176, 178, 179, 181
Rivets through fillers........... 81
Rocker bents 146
Rolled beams—arrangement in floors 99
" —depth of 51
" —where used 9
Rolled shapes—computed weight 261
Roller nests 91
Rollers—diameter of 91
" —finish of 250
" under girders 89
Rolling of material—notice of... 277
Rounded corners of thru girders 131
Scales 265
Scale weight 257, 259
Screw ends 86
Screw threads 251
Secondary stresses 47, 54, 105
Section of flanges of plate girders 117, 118, 119
Sections of truss members...... 136
Sheared edges—planing of....... 235
Shearing 209
Shear—splicing for 123
" —unit stress 38
Shelf angles 101
Shipping 266, 267, 268
" anchor bolts 268
" deck girder spans riveted.. 132
" long girders 267
" reamed parts 217
" statements 276
" —weighing and..257 to 268, incl.
" weight 257, 258, 259
Shoes and pedestals 8, 92
Shop assembling 222
Shop cleaning and painting..... 269
Shop drawings 5, 6, 7
" fits—responsibility for 6
" inspection 275, 279, 280, 281
" painting ....222, 269 to 274, incl.
Side flange plates............... 117
Single bents in viaducts........ 146
Size of rivets in angles.......... 62
Sizes of rivets................59, 227
Skew bridges 15
Skew portals—assembling....... 224
Sleeve nuts 87

Articles

Slotted holes for expansion..... 135
Sole and masonry plates in viaducts 154
Sole plates—planing 255
" " —slotted holes in..... 135
" " —thickness of.....134, 151
Solid floor connections.......... 103
" " sections—assembling.. 223
Solid floors—depth 51
" " —knee-braces 130
" " —lateral bracing...... 107
" " —live load........25, 26, 27
" " —proportioning of..... 104
Spacing of girders...12, 115, 150, 151
" stiffeners 125
" stringers 98
" trusses, girders and floor beams 12, 115, 150, 151
Span—length for calculation..... 11
" —limits of 9
Spans shipped riveted........... 132
Specifications and drawings—differences between 3
Specimens—test—form of .... 169 to 174 incl., 189 to 191 incl., 203
" not annealed 169
Specimen tension tests of eye-bar material 160
Speed of testing machine....... 162
Splice plates—fit of............. 237
Splices 74, 75
" for shear and moment..... 123
" —indirect 80
" in flanges of girders....122, 242
" in web plates............... 123
" of tension and compression members 74, 75, 242
Stay plates 67, 68, 211
Steel—cast........8, 182 to 197 incl.
" —chemical and physical properties..157 to 179 incl., 182 to 194 incl.
" —rivet..156 to 159 incl., 161, 162, 168, 174, 175, 176, 178, 179, 181
" —structural...8, 156 to 181 incl.
" —unit weight of............ 260
Stiffened tension members...... 138
Stiffeners at bearing points..... 124
Stiffeners at points of concentrated loading 127
Stiffeners—bearing area......... 124
" —crimping of 124, 127
" —end 124
" —fillers under 237
" —fit of 237
" —intermediate ...125 to 128 incl.
" —omitting 126
" —spacing of 125
" —width of outstanding leg 124, 128
Stiffening angles on gussets and knee-braces 129, 130

Articles

Stitch rivets 60
Straightening in mill............ 179
" material 179, 208
Strength of connections......... 57
Stress—ambiguity of 16
" —combined 45, 46
" —lateral, in viaducts........ 34
" —resultant 44
" —proportioning for maximum total 18
" —reversal of 44
" —secondary 47, 54, 105
" —sheets 5
" —unit ....38 to 48 incl.
Stringer frames 102
Stringers—specifications for..... 97
" —connection to floor-beams 101
" —cross-frames 102
" —depth of 11, 96
" —facing of 240
" —spacing of 98
" —span length 11
Structural steel....8, 156 to 181 incl.
Struts—at bottom of towers.... 147
" —top lateral 111
Sub-punched and reamed holes 212, 215, 216
Superelevation 13
Surface defects 179
Surfaces in contact—painting.. .... 222, 270
" —machine finished 274
Sway bracing 109, 111
" frames 112, 152
Symmetrical connections 57

Templates metal 224, 225
Tension members—length of ... 50
" " —splices of......75, 242
" " —stay plates 68
" " —stiffened 138
Tension tests—cast iron......... 203
Tension—unit stress 38
Terms—definitions of 1
Test bar for cast iron.......... 202
Testing—cost of 278, 289
Testing machines 278
Testing machine—speed of...... 162
Tests—bend......165 to 168 incl., 188
Tests—full size.......282 to 289 incl.
" —number of..175, 176, 177, 189, 192, 193, 194, 204
Test specimens..169 to 174 incl., 189, 190, 191, 203
" " —annealing of.....169, 170
" " —form of..171 to 174 incl.
" " —furnishing of 278
Tests—transverse 205
Thicknesses of metal—limiting.. 58, 65, 69, 92, 113, 117, 118, 120, 134, 141, 143, 154
Thickness—flange cover plates.. 118

Articles
Thickness of web plates........ 120
" —permissible variation in.. 180
Threads—screw 251
Through girders—ends of....... 131
" " —gusset plates 129, 130
Ties—distribution of load.....24, 121
" —impact 24
Timber floor 19, 95
" " —design of 24
" " —weight of 19
Top laterals 108, 111
Tower bracing 145, 153
Towers—anchorage for 155
Towers in viaducts.............. 145
" —bottom struts 147
Tower spans 144
Tracings—property of Company. 5
Track—weight of 19
Tracks—multiple 23
Tractive force 37
Transverse floor-beams—load on 25
Transverse girders 151, 153
Transverse tests for cast iron... 205
Trestle bents 145, 146
Trestle towers 145
Trusses ....136 to 143 incl.
" —camber 137
" —depth of 11, 51
" —distance center to center 12
" —end posts 109, 136
" —hip verticals 138
" —limiting lengths 9
" —number of 10
" —sections of members...... 136
" —spacing of 12
" —span length 11
" —stiff bottom chords....... 138
" —stiff tension members.... 138
" —top and bottom chords.. 136
" —type of 136
Trusses—web system 136
Turnbuckles 56
Turned bolts 85, 234
" " —allowance for...... 38
Type of end post of trusses..... 136
" of top and bottom chord of trusses 136
" of trusses 136
" of viaduct 144
" of web members of trusses 136
Types of bridges................ 9
" of floors 95

Uniform load 25
Unit stresses 38
Unit stresses and proportioning of parts ....38 to 48 incl.
Upset ends 86
Variation in weight..........258, 259
Variations in weight and thickness—permissible 180

Articles
Viaducts ....144 to 155 incl.
" —batter of columns........ 148
" —bents and towers.....145, 146
" —depth of girders.......... 149
" —girder connections and bracing 152, 153
" —lateral stresses 34
" —spacing of girders....150, 151
" —sole and masonry plates.. 154
" —type of 144
Washers 85, 135, 234, 268
" for anchor bolts........135, 268
Waterproofing—weight of 19
Web members 136
" " —proportioning of... 43
Web plates 120, 238, 239
" " —connection to flanges 121
" " —splices in 123
" " —thickness of 120
Webs of compression members —limiting thickness 65
Web splices 123
Weighing and shipping......... .... 257 to 268 incl.
Weighing and shipping—handling material for........... 265
Weighing of members.......... 265
Weight—computed...260 to 264 incl.
" marked on large members. 266
" of castings 264
" " plates 180, 262
" " rails and fastenings.... 19
" " reinforced concrete 19
" " rivet heads 263
" " rolled shapes 261
" " steel 260
" " timber 19
" " Waterproofing 19
" paid for 257
" variation in 180, 258, 259
Weights—estimated..258 to 264 incl.
" of individual members.... ....258, 266, 276
" —shipping 257, 258, 259, 265
Welds 252
Wide plates—computed weight.. .... 180, 262
Wide plates—percentage of overrun 180, 262
Width—clear 13
" of span 12
" —outstanding leg of stiffeners 124, 128
Wind load 17, 32, 33, 34, 35
Wind load stress combined with other stresses 46
Workmanship ....206 to 256 incl.
" —class of 206
" —general 207
" and finish at foundry....... 195
Yield point.....157, 161, 184, 187, 284

[12] RULES AND UNIT STRESSES FOR RATING EXISTING BRIDGES.

(1) In fixing the carrying capacity of any bridge under traffic, its location, design, details, material, workmanship, behavior, and physical condition must be taken into account.

(2) Before recalculating an existing bridge, a careful inspection should be made to determine:

(a) Whether the actual sections and details conform to the drawings.

(b) The loss of metal due to corrosion and wear. This determination should be made by calliper measurements, after thorough removal of scale.

(c) The general physical condition. Defects such as loose rivets, worn pins, crooked or damaged members, cracked metal, etc., should be carefully noted.

Particular attention should be given to the position of the track with respect to center line of the bridge, and to undesirable details, such as forked ends of compression members, eccentricity in riveted joints and connections, unequal stress in tension members, etc.

(3) In recalculating bridges for increased loading, the equipment in actual use, or which it is proposed to use, shall be taken for determining the live load stresses. Where the design or details are such as to cause eccentric or unusual secondary stresses, these stresses shall be taken into account. It is recommended that stresses in members subject to marked secondary effects be determined by strain gage measurements.

(4) In spans exceeding 150 feet in length, and in viaduct towers, the effect of lateral (or wind) force shall be taken into account. The lateral force shall consist of a moving load equal to 15 lb. per square foot on the vertical projection of the structure on a plane parallel with its axis, and a moving load of 400 lb. per linear foot applied 8 ft. above the base of rail.

(5) On curves, the centrifugal force, based on actual speed of operation, and assumed to act 6 ft. above the base of rail, shall be taken into account.

(6) Where speeds may exceed 15 miles per hour, the dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula

$$I = S\frac{300}{300 + \frac{L^2}{100}}, \text{ in which}$$

---

[12] Adopted, Vol. 22, 1921, pp. 379, 1008.

I = impact or dynamic increment to be added to the live load stress.
S = computed maximum live load stress.
L = the length in feet of the portion of the span which is loaded to produce maximum stress in the member.

Where maximum live load stress is produced by heavy cars or electric locomotives, impact stresses shall be taken as one-half of those given by the formula above.

(7) If a bridge is so located that speeds are definitely limited, or where absolute control of speed can be secured, 50 per cent. of the impact given by the above formula shall be used when the speed is between 10 and 15 miles per hour, and 25 per cent. when the speed is less than 10 miles per hour. If the bridge is located where the locomotive must be started, the speed increased, or the brakes applied, full impact shall be used in the calculations.

(8) Impact shall be added to stresses produced by centrifugal force, but not to those produced by lateral forces.

(9) For bridges on curves, and at other places where tracks are off center, consideration shall be given to the increased load carried by any truss, girder, or floor member due to the eccentricity of the load.

(10) The limiting stresses resulting from the loads and forces mentioned in the preceding articles, in combination with the actual dead load, shall not exceed the following, in pounds per square inch:

	Open-Hearth Steel	*Wrought Iron and Bessemer Steel*
Axial tension (net section)	26000	22000
Axial compression (gross section)	$24000-80\frac{l}{r}$	$21000-70\frac{l}{r}$
but not to exceed	20000	17000

l = length of the member in inches.
r = least radius of gyration of the member in inches.

Tension in extreme fibers of rolled shapes (except rolled beams), built sections and girders (net section)	26000	22000
Tension in extreme fibers of rolled beams (net section)	24000	20000
Compression in flanges of plate girders and I-beams (gross section)	$26000-300\frac{l}{b}$	$22000-250\frac{l}{b}$
but not to exceed	24000	21000

l = length in inches of the unsupported flange, between lateral connections or knee braces.
b = flange width in inches.

Tension in extreme fibers of pins (figured by assuming stresses concentrated at centers of bearings)	50000	40000
If the members are packed closely on the pin, the bending stress need not be considered unless the tension in extreme fiber exceeds 60000 lb. per sq. in. for open-hearth steel, or 50000 lb. per sq. in. for wrought iron and Bessemer steel.		
Shear in plate girder webs and rolled beams (gross section)	18000	15000
Shear in rivets and pins	22000	19000
Bearing on rivets, pins, outstanding legs of stiffener angles, and other steel parts in contact	44000	38000
The above-mentioned values for shear and bearing shall be reduced 20 per cent. for countersunk rivets, floor connection rivets, and turned bolts.		

(11) In members subject to stresses produced by a combination of dead load, live load, impact, centrifugal force, and eccentric application of dead and live load, with lateral forces, or bending due to lateral action, unit stresses 25 per cent. greater than those given in Article 10 may be allowed; but, in such cases, the unit stresses due wholly to dead load, live load, impact, centrifugal force, and eccentric application of dead and live load shall not exceed those given therein.

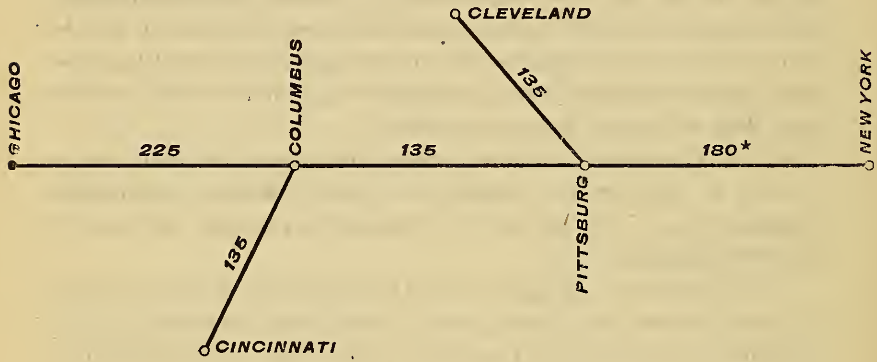
(12) In hangers having an unequal distribution of load, and in hangers or hip verticals consisting of a single member, consideration should be given to the necessity for reducing the allowable unit stress to meet this condition.

(13) Stresses in plate girders shall be computed either by the moment of inertia of their net sections; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if continuous or properly spliced, may be used as flange section. For girders having unusual sections, the moment of inertia method shall be used.

(14) When the stresses exceed the foregoing limits, or when the design or physical condition makes it necessary, the structure shall be strengthened or renewed. When these limits are closely approached, or when the physical condition of the structure is not good, it shall be kept under close inspection as long as it is continued in service.

[13]CLASSIFICATION OF BRIDGES FOR OPERATING PURPOSES.

(1) Bridges should be classified for operating purposes according to their efficiencies under a loading of the type outlined in the American Railway Engineering Association specifications. The efficiencies should be indicated by figures representing either the total weight or driving axle weight of the heaviest permissible engine of the specification type, and these figures should be placed on the map of the railway in such a manner as to show at a glance the capacity of the weakest structure on the main line, branches and engine districts. A schedule on this map will give the service classes of engines and cars whose operation is permitted by the stated efficiencies. Notes on the map will indicate restrictions as to speed and doubleheaders, and in order that these notes may not be overlooked an asterisk may be placed after the number indicating the efficiency on that section of the road where there are restrictions as to doubleheaders and speed. The accompanying map illustrates briefly the above scheme.



Schedule showing heaviest equipment of each service class which may be operated when the bridge efficiency is stated:

Efficiency.	*Service Class.*			
225	A250	B240	C130	D220
180	A200	B190	C180	D170
135	A150	B140	C130	D120

The figures denote weight in 1000 lbs. of engine, exclusive of tender.

Speed restriction: Ten miles on Bridge 23 at Pittsburgh.

Doubleheaders: No restriction except ....

---

[13] Adopted, Vol. 9, 1908, pp. 218-221, 285-296.

Note.—If preferred, the efficiency may be indicated by the driving axle-load in accordance with Cooper's series instead of by the weight as above shown.

[14] PRINCIPLES FOR DETAILED DESIGN OF FLASHING, DRAINAGE, REINFORCEMENT AND PROTECTION FOR WATERPROOFING PURPOSES.

General.

1. The following applies only to membrane waterproofing, as the "integral method" is not recommended for waterproofing railroad bridge floors.

2. The structure should be designed so that it can be waterproofed and it should be adaptable to waterproofing by ordinary methods and materials.

Good workmanship being vital to the success of waterproofing, the design should be such that extraordinary precautions or methods will not be necessary to secure good results.

3. Strength and stiffness are desirable features in a structure which is to be waterproofed.

The lack of these may permit destructive stresses in the waterproofing. Very shallow floors, such as shown in Figs. 3 and 4, should be avoided wherever possible.

4. The structure and its construction and expansion joints, drainage and waterproofing, should be designed together, considering their separate and combined functions, so that each will help to secure a waterproof structure.

If any necessary feature is overlooked, it may be difficult, if not impossible, to provide a remedy after trouble appears.

5. Due regard should be had for the available methods and materials of construction.

Traffic conditions, climate and prevailing markets or supplies, might thus control the design. Wherever possible, waterproofing under traffic should be avoided.

6. All waterproofed surfaces should be easily accessible, and as simple and smooth as possible; hence features should be avoided which would increase the difficulty of securing waterproof construction, such as open spaces, joints, holes, seams, or projections.

The deck bridges shown in Figs. 15 and 16 lend themselves more readily to successful treatment than the trough floors, Figs. 2, 3 and 4, or the through bridges, Figs. 8, 9, 10, 11 and 13.

7. Concrete bridge floors should be of ample strength and thickness and of dense non-porous construction.

Special attention should be given to providing the correct amount and disposition of the reinforcement, and to securing the proper amount of water used in mixing. (See Figs. 5 to 10, 13, 15 and 16.)

---

[14] Adopted, Vol. 22, 1921, pp. 395, 1019.

8. Where contraflexure would injure the waterproofing, special details should be provided, such as elastic joints. (See Figs. 7 and 15.)

9. Minimize the number of construction joints in the structure, provided an ample number of workable expansion joints can be introduced.

Concrete bridge floors should, where practicable, be built in one continuous operation for each track.

Drainage.

10. Adequate drainage should be provided by means of suitable grades which will shed water by the easiest or most direct route. One per cent. is a minimum desirable grade, but the grades away from points which are difficult to waterproof, should be correspondingly increased.

While sewer and gutter grades may be considerably less than one per cent., bridge floors, especially if ballasted, are subject to clogging by ashes, cinders, etc., and hence require steeper slopes to secure satisfactory drainage. (See Figs. 1, 2, 3, 4, 8 and 15.)

11. Avoid pockets which cannot be easily drained.

Water with only a slight head may find an outlet through the waterproofing, which otherwise might be tight. Standing water is undesirable on a waterproofed bridge floor, from its destructive effect, both as a solvent and also on account of frost action.

12. Where gutters or pipes are necessary, they should be of durable material, of ample size, easy of access to install and maintain, and protected against clogging or damage.

The grades should be enough to secure quick and entire escape of the water. Corrugated metal pipes are satisfactory where exposed to alternate freezing and thawing. Where sudden considerable variations in temperature occur, it is not desirable to encase drain pipes in concrete. Cleanouts and manholes should be provided where pipes cannot otherwise be cleaned. (See Figs. 3, 4, 8, 10, 12, 14, 15 and 16.)

13. Provide free exits for the harmless escape of drainage.

Such drainage should not be allowed to disfigure the structure nor to injure persons or property. Icicles may be prevented by a basket of rock salt inserted in the top of the drain pipe. (See Figs. 3, 4, 11, 12, 14, 15 and 16.)

14. Avoid features which would induce or permit capillary action.

For example, where the waterproofing extends up under the top of flange or beneath a flashing angle, it is very desirable to make the water drip off the edge, rather than allow it to follow the under surface and be drawn into the crack. (See Figs. 6, 7, 8 and 16.)

15. Where possible, locate edges and joints above the highest probable water level.

Edges of the waterproofing, either at parapets or where it joins the webs of through girders, should be at least as high as the base of rail, and preferably higher than the top of rail. Joints in the floor should be located so that the grades slope away from the joint.

Reinforcement.

16. Reinforcement of the structure should be suitably disposed, and ample in strength to prevent cracks or distortion which would injure the waterproofing. (See Figs. 6, 8, 9, 10, 13, 15 and 16.)

Reinforcement should be protected against destructive agencies such as electrolysis, brine, etc.

17. Cloths, felts or fibers should be capable of holding the waterproofing pitch where placed and should be durable, strong and flexible.

18. Wire mesh or sheet metal reinforcement for the membrane should be of durable material, flexible where necessary, and intimately bonded or introduced so that the waterproofing and reinforcement act together. (See Figs. 7 and 15.)

19. Necessary breaks in the surface of waterproofing or flashing, such as for drain pipes, or at construction or expansion joints, should be reinforced with extra flashing material. (See Figs. 7 and 15.)

Flashing.

20. Metal flashing should be of material which is non-corrosive, and should be insulated or protected against electrolytic action at points of contact with steel members of the structure. (See Figs. 5, 7, 8, 13 and 15.)

21. Flashing should be of material which can be applied readily, and should retain the position in which it is placed when subjected to actual conditions of service and temperature.

22. Flashing should be firmly attached in its proper position, so that it cannot easily be displaced or removed. (See Figs. 13 and 15.)

23. The edges of waterproofing and flashing should be protected against drip, percolation and capillary action. (See Figs. 5, 6, 7, 8, 9, 10, 11, 13 and 15.)

24. Joints between concrete and other material should be grooved and filled with an elastic expansion joint cement. (See Figs. 1 and 9.)

Protection.

25. Waterproofing and flashing should be protected, *as soon as possible after installation,* against mechanical injury, excessive temperature, chemical action and deterioration caused by exposure to light and air.

26. The protecting covering should be dense, hard, durable and easy to apply.

It is recommended to use on flat surfaces one of the following:

(a) Brick laid in cement mortar or served with hot pitch.
(b) Plain or reinforced cement mortar.
(c) Plain or reinforced concrete.
(d) Bituminous mastic.

For surfaces with considerable slope, mastic is not satisfactory, being difficult to apply and also to retain in place.

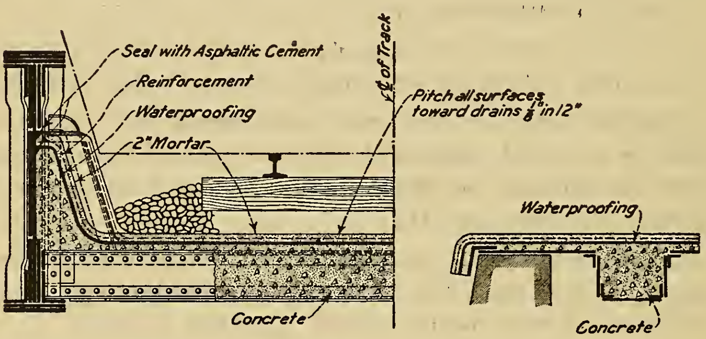


FIG. 1

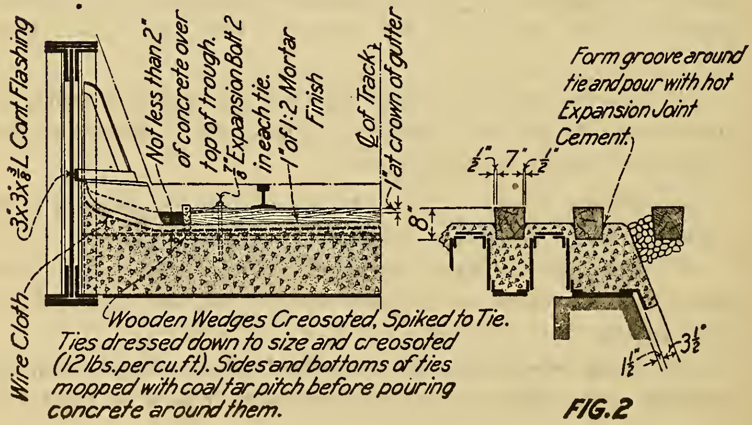

3"x3"x3/8" L Cont. Flashing
Wire Cloth
Not less than 2" of concrete over top of trough.
7/8" Expansion Bolt 2 in each tie.
1" of 1:2 Mortar Finish
℄ of Track
1" at crown of gutter
8"
Wooden Wedges Creosoted, Spiked to Tie.
Ties dressed down to size and creosoted (12 lbs. per cu. ft.). Sides and bottoms of ties mopped with coal tar pitch before pouring concrete around them.
Form groove around tie and pour with hot Expansion Joint Cement.
1/2"
7"
1/2"
1 1/2"
3 1/2"

FIG. 2

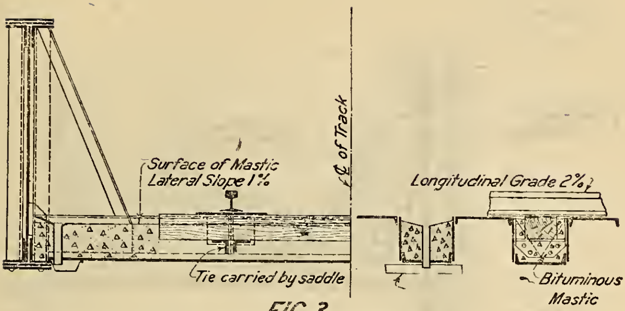


FIG. 3

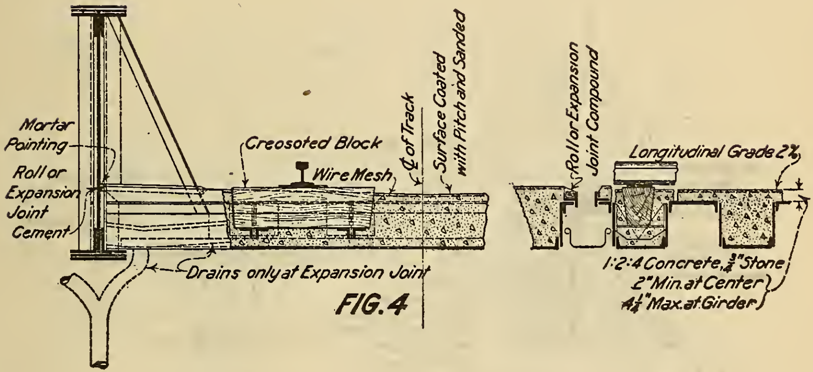

Mortar Pointing
Roll or Expansion Joint Cement
Creosoted Block
Wire Mesh
℄ of Track
Surface Coated with Pitch and Sanded
Roll or Expansion Joint Compound
Longitudinal Grade 2%
Drains only at Expansion Joint
1:2:4 Concrete, 3/4" Stone
2" Min. at Center
4 1/2" Max. at Girder

FIG. 4

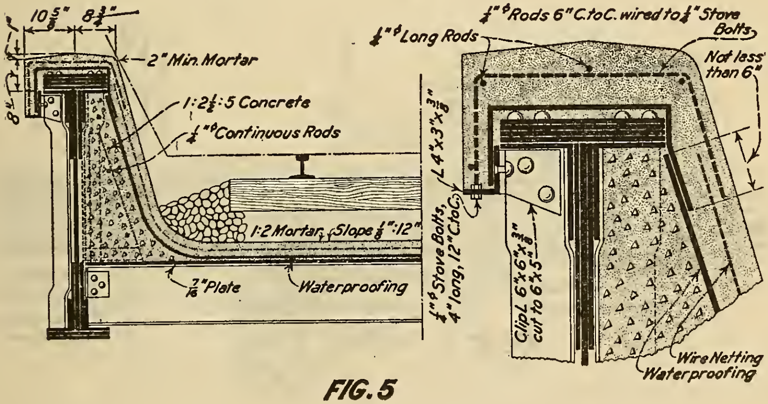


FIG. 5

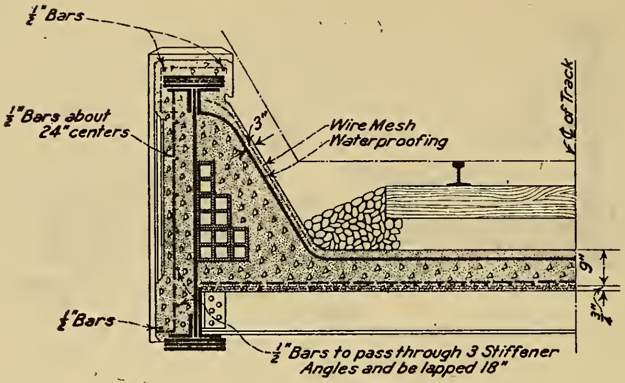

½" Bars
½" Bars about 24" centers
3"
Wire Mesh
Waterproofing
℄ of Track
9"
¾"
½" Bars
½" Bars to pass through 3 Stiffener Angles and be lapped 18"

FIG. 6

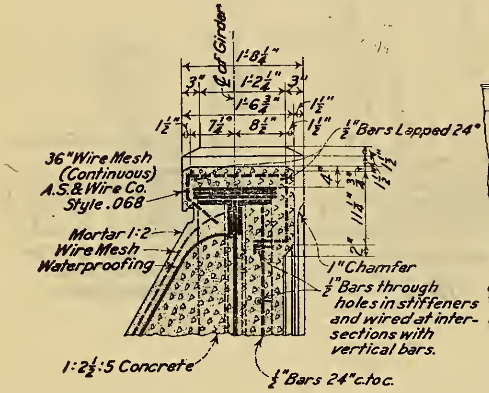
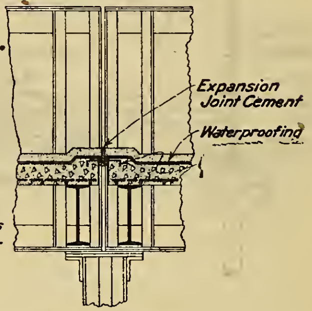


FIG. 7



DETAIL OVER COLUMN BENT

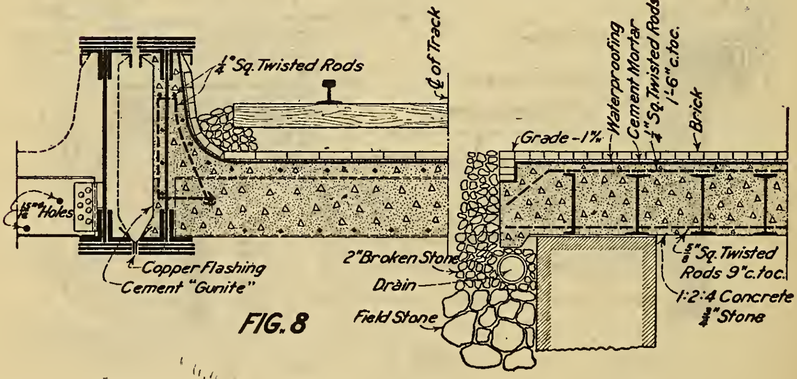


FIG. 8

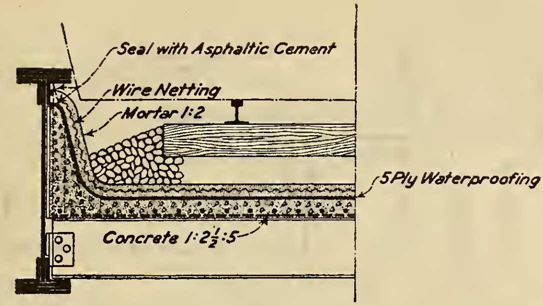


FIG. 9

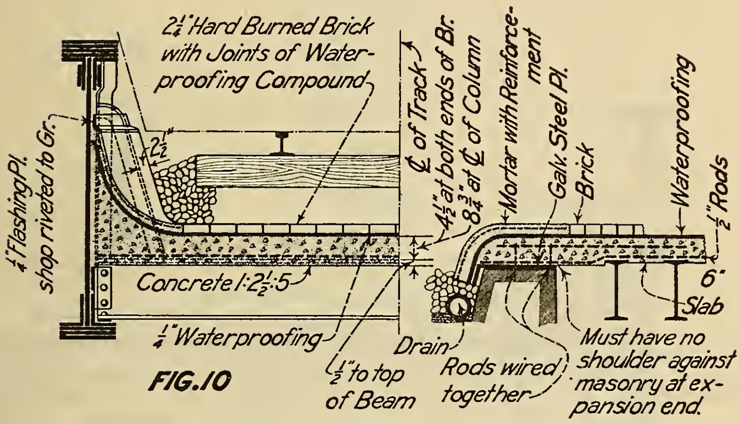

2¼" Hard Burned Brick with Joints of Waterproofing Compound
¼" Flashing Pl. shop riveted to Gr.
2½"
℄ of Track
4½" at both ends of Br.
8¾" at ℄ of Column
Mortar with Reinforcement
Galv. Steel Pl.
Brick
Waterproofing
½" Rods
6"
Slab
Concrete 1:2½:5
¼" Waterproofing
Drain
½" to top of Beam
Rods wired together
Must have no shoulder against masonry at expansion end.

FIG. 10

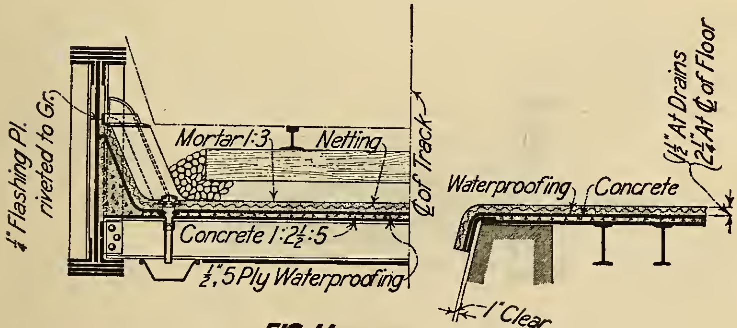


FIG. 11

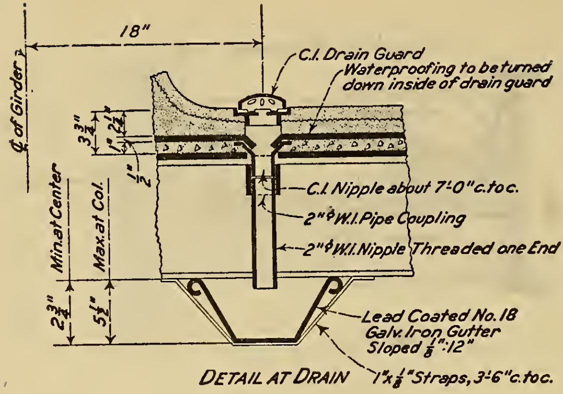

18"
℄ of Girder
C.I. Drain Guard
Waterproofing to be turned down inside of drain guard
3¾"
2¼"
1"
½"
C.I. Nipple about 7'-0" c. to c.
2"φ W.I. Pipe Coupling
2"φ W.I. Nipple Threaded one End
Min. at Center
Max. at Col.
2¾"
5½"
Lead Coated No. 18 Galv. Iron Gutter Sloped ⅛":12"
1"x⅛" Straps, 3'-6" c. to c.
DETAIL AT DRAIN

FIG. 12

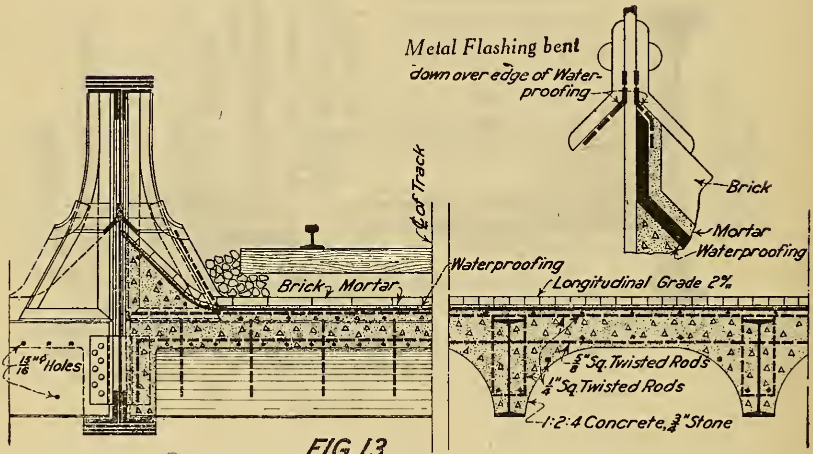


FIG. 13

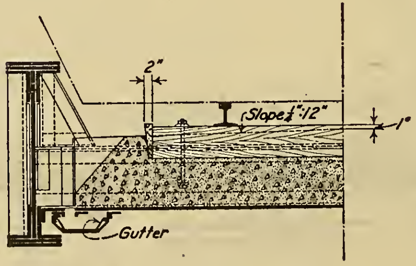


FIG. 14

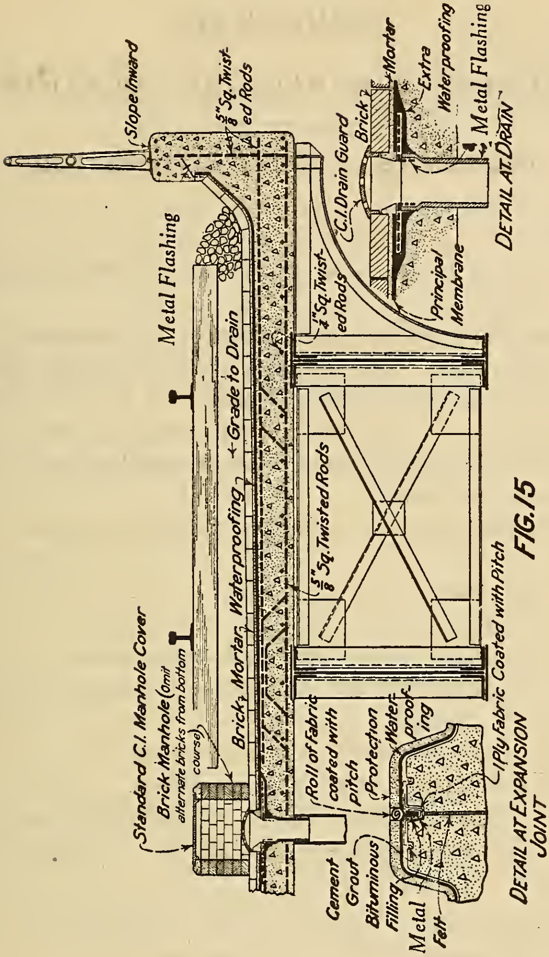

Slope Inward
5/8" Sq. Twisted Rods
Metal Flashing
Grade to Drain
Brick, Mortar, Waterproofing
5/8" Sq. Twisted Rods
1/4" Sq. Twisted Rods
Standard C.I. Manhole Cover
Brick Manhole (omit alternate bricks from bottom course)
Roll of Fabric coated with pitch
(Protection
Waterproofing
1 Ply Fabric Coated with Pitch
Cement Grout
Bituminous Filling
Metal Felt
DETAIL AT EXPANSION JOINT
C.I. Drain Guard
Brick
Mortar
Extra Waterproofing
Metal Flashing
Principal Membrane
DETAIL AT DRAIN

FIG. 15

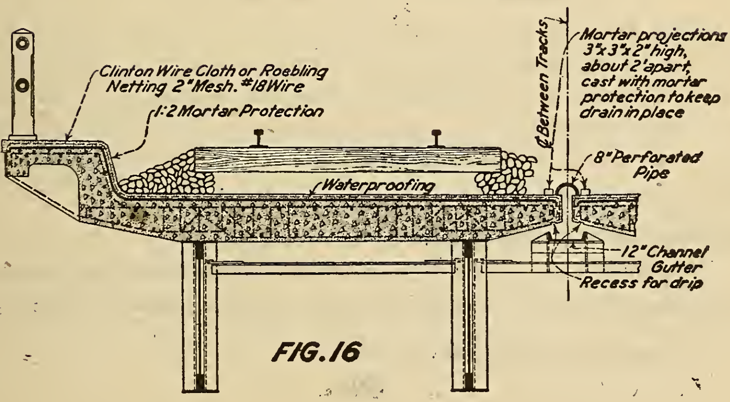

Clinton Wire Cloth or Roebling Netting 2" Mesh. #18 Wire
1:2 Mortar Protection
Waterproofing
℄ Between Tracks
Mortar projections 3"x3"x2" high, about 2' apart, cast with mortar protection to keep drain in place
8" Perforated Pipe
12" Channel Gutter
Recess for drip

FIG. 16

COMMITTEE XVI.

ECONOMICS OF RAILWAY LOCATION.

[1] ECONOMICS OF RAILWAY LOCATION.

Definitions.

(1) A line is located when its position is fixed horizontally and vertically.

(2) Locating a railway means designing an economical plant for handling a given traffic. The economical plant for a given quantity and class of traffic may not be the economical plant for a greater or less quantity of traffic or for traffic of a different class. It is considered good practice to discount the future within reasonable limits, provided the necessary funds are available.

(3) The most general formula for the economic value of a location is:

$$\frac{R-E}{C}=p \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where $R =$ Annual revenue (receipts from operation);

$E =$ Annual expense of operation, including depreciation and taxes;

$C =$ Capital invested (cost of construction);

$p =$ Percentage of profit on investment.

(4) The following equation may be used in certain cases, especially where the annual revenue, known or unknown, is constant:

$$R-(E+I)=P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where $I =$ Amount of interest on cost of construction;

$P =$ Amount of profit (net corporate income).

When the revenue is constant the condition of equation (2) is that the sum of operating expenses plus interest on cost of construction shall be a minimum. The equation is convenient in many cases, but does not indicate the proportion of profit to investment. Care should be taken not to use too low a rate of interest. The ratio of profit to investment should be considered.

Locations Governed by Traffic.

(5) In order to make a location on an economic basis, the Engineer must know, or make a reasonable assumption of, the amount, direction of

---

[1] Adopted, Vol. 16, 1915, pp. 104, 1078.

movement, and class of traffic which the railway will be called upon to handle, and the probable cost of operation. He must also consider variations in the amount and character of traffic that may be occasioned by changes in line, gradients or other features of location.

Engine Districts.

(6) The engine district should be sufficiently long to obviate constructive mileage and short enough to enable the maximum slow freight train to make the run within the hours of service required.

One of the necessary requisites for a terminal point is a suitable water supply for locomotives and for domestic use. It is desirable, where possible, that terminal points should be located on minor summits.

Passing Sidings.

(7) Passing sidings and road water supplies should preferably be located on minor summits.

(8) If passing sidings must of necessity be located on ruling gradients, then such gradients should, if practical, be compensated for the whole length of the siding and for a full train length beyond each end, so as to permit the maximum train load which can be hauled over the ruling gradient to be started from a full stop at any point within the limits given. Due consideration must also be given to the compensation required on the curves at each end of the turnout.

Ruling Gradients.

(9) In deciding upon the ruling gradient for an engine district, due consideration should be given to the following:

(a) The necessity and cost of breaking up trains, where the rate of ruling grade and adjoining districts varies.

(b) The possibility of utilizing different types or sizes of motive power.

(c) The balance between steep gradients and shorter distance, and lower rates of gradient and increased distance and curvature.

(d) The time element of increased distance.

(e) The loss of time at meeting points—especially on crowded single-track lines.

(f) The fact that a reduction of the rate of ruling gradient may have no effect on increasing the tonnage of passenger trains and very little on local and fast freights.

(g) The possibility of future revisions—and the utilization of the maximum amount of original work of construction.

Lessening First Cost.

(10) In the construction of a line where the contemplated immediate traffic is small and the future traffic large, sharp curvature and steep temporary gradients, so situated as to be capable of reduction when justified by the traffic, may be advantageously introduced; a line being thus constructed which will provide for immediate requirements and which can be improved for future requirements at a reasonable expense. Before deciding upon such temporary expedients, care should be taken to compare the cost of the work ultimately to be abandoned with the interest saved on the extra cost of construction that would have been necessary to construct a line on the final location during that period in which the more expensive construction would appear uneconomical.

In the construction of temporary lines due consideration must be given to the location of stations, and these should not be located on portions of the line where revisions are contemplated, owing to the fact that if a receiving and delivery point for local traffic is once established, opposition from the public may prevent its removal.

In the matter of terminal property the future requirements should be estimated for a longer period than is justified for the line between terminals.

Momentum Gradients.

(11) Momentum gradients, not exceeding that over which a locomotive loaded for the ruling gradient can handle its train in two parts if stalled for any reason in the sag, may be used to reduce the construction cost without decreasing the train rating or the efficiency of the railway, and should be used where economy in construction cost is thereby effected, except at points where train stops or reduced speed, below the limit necessary to operate the gradient, are likely to be necessary.

In the calculation of the lengths of momentum gradients the maximum speed of freight trains at the bottom of the sag should not exceed the speed limit for such trains on the engine district under consideration; and the minimum speed at the top of the gradient, where the velocity gradient adjoins an ascending gradient of any considerable length, should not be less than 11 miles per hour. Where the top of the momentum gradient is at a summit, the minimum speed may be less than 11 miles per hour.

In fixing the grade line for any alinement, care should be taken to insert vertical curves at all grade-line intersections. Curves should be connected to tangents by spiral or easement curves of such length as to provide ample space in which to make the required elevation, giving due consideration to future requirements of increased speeds.

Comparison of Alternate Locations.

(12) The location of terminal points, ruling gradient, and pusher gradients having been decided upon, the effect of the minor details of location, namely, distance, curvature, and rise and fall, upon operating expenses may be determined approximately in the following manner:

Alternative locations may be compared by distance, curvature and line resistance. Distance is the length of the line measured along the center line of the location. Curvature is the number of degrees of central angle subtended by the center line of track; it may be divided into sharp curvature, necessitating a reduction of speed for trains, and ordinary curvature, which will again be subdivided into that increasing line resistance in both directions and that increasing line resistance in one direction only. Line resistance is the sum of the rolling resistance (or friction resistance), plus the resistance of gravity overcoming difference in elevation on ascending grades, plus the resistance due to curvature, minus the energy of gravity on trains on descending grades, from which has been subtracted the loss of energy (or velocity head) due to the application of brakes.

In comparing different locations the resistance under average conditions should be used.

Train Resistance.

(13) The above method must be understood to disregard the resistance due to accelerating trains. This may or may not be a considerable part of the total resistance, depending on the rates of grade and the distances between stops.

The frictional resistance of freight trains under normal conditions in warm weather with modern equipment running at speeds between 7 and 35 miles per hour may be determined with sufficient accuracy for the purpose of comparing different gradients and locations by the formula

$$R = 2.2\ T + 121.6\ C$$

where R = Total resistance on level tangent;
T = Total weight of cars and contents in tons;
C = Total number of cars in train.

The values thus obtained will usually be from 4 to 8 lb. per ton and a fair average for mixed traffic may be taken at 6 lb. per ton. For convenience in the comparison of two or more locations the total resistance may be converted into feet of rise. Thus, 1 lb. per ton resistance is practically equivalent to 2½ ft. of rise per mile. Train resistance increases at lower temperatures and at extremely low temperature may be so great as 30 lb. per ton for empty freight cars. Normal conditions should be assumed for the comparison of different locations in the same country. The resistance due to curvature may be assumed to be equivalent to 0.04 ft. of rise for each degree of central angle.

Minor Details.

(14) To determine the relative value of the minor details of location under consideration (curvature, distance, rise and fall), it is first necessary to decide upon a method of studying the effect of these factors on the cost of operation. Curvature increases the resistance by about 0.8 lb. per ton per degree of central angle, which is equivalent to a rise of 0.04 ft. per degree of central angle; it also affects the cost of maintenance of way and the cost of maintenance of equipment, but sufficient data is not available to warrant a conclusion as to the definite amounts.

Inertia resistance, or the additional energy required to increase the velocity of a train from V_1 velocity to V_2 velocity may be computed by the formula:

$$P = (V_2^2 - V_1^2)\frac{70}{s},$$

where P = required force in pounds per ton;

V_2 and V_1 = the higher and lower velocities respectively in miles per hour;

s = distance in feet in which such acceleration is accomplished.

For many calculations V_1 = zero. The formula allows 5 per cent. for the extra energy required to produce rotation of the wheels and axles.

Rise and fall affect line resistance and may affect time, but to what measurable extent is indeterminate. The amount of rise and fall of each alternate location in vertical feet should generally be determined and considered as an aid to judgment in forming final decision as between locations, but may be neglected entirely in comparing alternate locations where there is small difference in rise and fall.

Distance affects train wages, line resistance, maintenance of way and maintenance of equipment. The effect of distance on line resistance will be found in the fuel account. The effect of distance on train wages can be computed on a direct train-mile basis. The effect of distance on maintenance of way is a more complicated problem on account of the uncertainty as to the basis on which maintenance should be calculated. A fixed sum per mile to cover factors of maintenance that are more or less constant plus a rate for the equivalent ton-mile unit, using multiples for weights of engines and passenger cars, is correct in principle, but until such time as information is obtained as to the value of these multiples, this item may be calculated on the basis of a constant per mile plus a fixed sum per train mile. The effect of distance on maintenance of equipment, for comparative purposes, may be calculated on a train-mile basis.

Special Structures.

(15) The maintenance and operation of special structures must be considered on their respective merits for each location.

Time.

(16) Time will not as a general thing constitute an important factor in the consideration of the minor details of location, but if the difference in time required to operate over alternative locations is of sufficient importance to affect the amount of equipment to operate the line, and consequently the annual charge for same, or the earnings of the line, or the trainmen's wages through overtime, then this item must be taken into consideration.

Distance and Revenue.

(17) In comparing lines of varying lengths, consideration must be given to the effect of distance upon revenue. Another item worthy of consideration is the fact that reducing distance in engine runs of less than 100 miles, which constitute the entire day's work for trainmen employed on same, may not reduce the amount of wages to be paid to such employees.

[2]POWER.

(1) Actual drawbar pull of the locomotive at various speeds should be used in making estimates with reference to economic value of various locations of line and gradient, where such drawbar pull is known. Where not known, the drawbar pull should be calculated. In comparing a new line with an existing line the same percentage of efficiency of drawbar pull should be used in both cases.

(2) The tractive power of a locomotive depends upon its steam-producing capacity, the boiler pressure, the adhesion, and the size of the cylinders and drivers.

(3) The steam-producing capacity of a locomotive depends mainly upon the quantity and quality of the fuel burned, and the area of heating surface.

(4) Knowing the area of heating surface, the average steam production of locomotives burning bituminous and similar coals can be estimated by the use of Table 1, assuming the maximum quantity of coal that can be properly fired and consumed per hour, to be as follows:

---

[2] Adopted, Vol. 11, Part 1, 1911, pp. 631-664, 709-715; Vol. 16, 1915, pp. 138, 1067.

Hand-fired locomotives..................................4,000 lb. per hour
Stoker-fired locomotives with grates less than 70 square feet........
....6,000 lb. per hour
Stoker-fired locomotives with grates of 70 square feet or over.......
....8,000 lb. per hour

These amounts are to be understood as the average hourly fuel consumption which may reasonably be expected to be maintained throughout the periods when the locomotive is working steam.

(5) The maximum velocity at which full cutoff can be maintained can be found by dividing the pounds steam produced per minute by the quantity of steam used per revolution of the drivers, as shown in Table 2. Dividing this quotient by the coefficient given in Table 3 for the diameter of the drivers will give the speed in miles per hour at which full cutoff can be maintained. This velocity is referred to as "M" in the tables.

(6) Tractive power of a locomotive is greatest at starting, gradually reducing to the maximum velocity ("M") at which full cutoff can be maintained. At speeds above this velocity the tractive power decreases more rapidly. The tractive power at any multiple of "M" is practically a fixed percentage of the tractive power at "M." The fixed percentages are different for compound types than for simple locomotives.

(7) Knowing the steam production of a locomotive and the maximum velocity at which full cutoff can be maintained ("M"), the indicated horsepower of the locomotive can be obtained for velocity "M" or higher velocities by dividing the total steam produced per hour by the quantity of steam used per I.H.P. hour, as given in Table 4, after applying the corrections for proper boiler pressure in the case of a locomotive using saturated steam.

(8) Horsepower can be converted into tractive power by the formula, tractive power equals 375 times the H.P., divided by the velocity in miles per hour. To simplify the operation, the tractive power can be obtained by multiplying the H.P. by the figures shown in Table 6.

(9) Where I. H. P. at "M" velocity has been converted into cylinder tractive power, the cylinder tractive power at other multiples of "M" can be determined by using the percentages given in Table 5 without first calculating the I.H.P. for the respective multiples of "M."

(10) Available drawbar pull on level tangent is the cylinder tractive power less the sum of the resistance from the cylinder to the rim of

drivers, the resistance through the trucks of engine and tender, and the "head end" or velocity resistance. The formulas and data given in Table 7 are recommended for use in determining these resistances. Available drawbar pull at starting, with use of sand, should not be considered as greater than 30 per cent. of the weight on locomotive drivers and at running speeds not greater than 25 per cent.

TABLE 1

Average Evaporation in Locomotive Boilers

Burning bituminous and similar coals of various qualities and for various quantities consumed per square foot of heating surface per hour.

Based on Feed Water at 60° Fahrenheit. Boiler Pressure, 200 lbs.

Lbs. Coal per Sq. Ft. H. Surface per Hour	Pounds Steam per Pound of Coal of Given Thermal Value					
	10,000 B. T. U.	11,000 B. T. U.	12,000 B. T. U.	13,000 B. T. U.	14,000 B. T. U.	15,000 B. T. U.
0.8	5.24	5.76	6.29	6.81	7.34	7.86
0.9	5.05	5.56	6.06	6.57	7.07	7.58
1.0	4.87	5.36	5.85	6.34	6.82	7.31
1.1	4.71	5.18	5.65	6.12	6.59	7.06
1.2	4.55	5.00	5.46	5.91	6.37	6.82
1.3	4.39	4.83	5.27	5.71	6.15	6.59
1.4	4.25	4.67	5.10	5.52	5.95	6.37
1.5	4.11	4.52	4.94	5.35	5.76	6.17
1.6	3.98	4.38	4.78	5.18	5.57	5.97
1.7	3.86	4.25	4.63	5.02	5.40	5.79
1.8	3.74	4.12	4.49	4.86	5.24	5.61
1.9	3.63	3.99	4.35	4.71	5.08	5.44
2.0	3.51	3.86	4.22	4.57	4.92	5.27
2.1	3.41	3.75	4.10	4.44	4.78	5.12
2.2	3.31	3.64	3.98	4.31	4.64	4.97
2.3	3.22	3.54	3.86	4.19	4.51	4.83
2.4	3.13	3.44	3.75	4.07	4.38	4.69
2.5	3.04	3.34	3.65	3.95	4.26	4.56
2.6	2.96	3.25	3.55	3.84	4.14	4.44
2.7	2.88	3.17	3.46	3.74	4.03	4.32
2.8	2.80	3.09	3.37	3.64	3.93	4.21
2.9	2.73	3.01	3.28	3.55	3.83	4.10
3.0	2.66	2.93	3.19	3.46	3.73	3.99

The quantity of steam evaporated for intermediate quantities or qualities of coal can be found by interpolation.

On bad water districts deduct the following from tabular quantities:

For each $\frac{1}{16}$-inch of accumulated scale ....10 per cent.

For each grain per U. S. gallon of foaming salts in the average feed water............................. 1 per cent.

For locomotive using superheated steam, the heating surface mentioned in column 1 is to be understood as total water-heating surface only—superheating surface is not included.

TABLE 2

WEIGHT OF STEAM USED IN ONE FOOT OF STROKE IN LOCOMOTIVE CYLINDERS.

(a) For locomotives using saturated steam.

Cylinder diameter is for high pressure cylinders in compound locomotives.

Diameter of Cylinder in Inches	WEIGHT OF STEAM PER FOOT STROKE FOR VARIOUS GAGE PRESSURES						
	160 lb.	170 lb.	180 lb.	190 lb.	200 lb.	210 lb.	220 lb.
12	0.304 lb.	0.321 lb.	0.337 lb.	0.354 lb.	0.370 lb.	0.389 lb.	0.405 lb.
13	0.357 "	0.376 "	0.396 "	0.415 "	0.435 "	0.456 "	0.475 "
14	0.414 "	0.436 "	0.459 "	0.482 "	0.504 "	0.529 "	0.551 "
15	0.476 "	0.501 "	0.527 "	0.553 "	0.579 "	0.607 "	0.633 "
15½	0.508 "	0.535 "	0.562 "	0.590 "	0.618 "	0.649 "	0.675 "
16	0.541 "	0.570 "	0.599 "	0.629 "	0.658 "	0.691 "	0.720 "
17	0.611 "	0.643 "	0.676 "	0.710 "	0.744 "	0.780 "	0.812 "
18	0.685 "	0.722 "	0.759 "	0.796 "	0.834 "	0.875 "	0.911 "
18½	0.724 "	0.762 "	0.801 "	0.841 "	0.881 "	0.924 "	0.962 "
19	0.763 "	0.804 "	0.845 "	0.887 "	0.928 "	0.975 "	1.015 "
19½	0.804 "	0.847 "	0.890 "	0.934 "	0.978 "	1.027 "	1.069 "
20	0.846 "	0.891 "	0.936 "	0.983 "	1.029 "	1.080 "	1.125 "
20½	0.888 "	0.936 "	0.984 "	1.032 "	1.081 "	1.134 "	1.181 "
21	0.932 "	0.982 "	1.032 "	1.083 "	1.134 "	1.191 "	1.240 "
22	1.023 "	1.078 "	1.133 "	1.189 "	1.245 "	1.307 "	1.361 "
23	1.118 "	1.178 "	1.238 "	1.300 "	1.361 "	1.428 "	1.487 "
28	1.657 "	1.745 "	1.835 "	1.926 "	2.017 "	2.117 "	2.204 "

For weight of steam used per revolution of drivers at full cutoff:—Multiply the tabular quantity by four times the length of stroke in feet for simple and four cylinder compounds. For two cylinder compounds multiply by two times the length of stroke.

(b) For simple locomotives using superheated steam.

Diameter of Cylinder in Inches	WEIGHT OF STEAM PER FOOT OF STROKE FOR VARIOUS GAGE PRESSURES					
	160 lb.	170 lb.	180 lb.	190 lb.	200 lb.	210 lb.
18	.415	.443	.470	.498	.524	.551
19	.465	.496	.526	.557	.587	.618
20	.515	.549	.582	.617	.650	.684
21	.565	.605	.641	.679	.715	.752
22	.623	.665	.705	.747	.787	.827
23	.682	.728	.772	.818	.861	.905
24	.741	.791	.838	.889	.931	.984
25	.804	.859	.910	.965	1.016	1.065
26	.868	.927	.983	1.041	1.097	1.150
27	.937	1.000	1.057	1.123	1.183	1.241
28	1.008	1.078	1.143	1.209	1.275	1.340
29	1.083	1.156	1.225	1.299	1.368	1.438
30	1.157	1.234	1.308	1.387	1.460	1.533

This assumes a superheat of 200 degrees Fahrenheit, and a drop of 5 lb. per square inch in pressure between the boilers and the cylinders.

TABLE 3

VALUES OF COEFFICIENT "C" FOR CHANGING REVOLUTIONS PER MINUTE OF DRIVERS INTO VELOCITY IN MILES PER HOUR.

$$\text{``}C\text{''} = \frac{336.13}{\text{Diameter of drivers in inches.}}$$

$$\text{Miles per hour} = \frac{\text{Revolutions per minute}}{\text{``}C\text{''}}$$

Diam.	"C"	Diam.	"C"	Diam.	"C"	Diam.	"C"
50 in.	6.72	58 in.	5.79	66 in.	5.09	74 in.	4.54
51 "	6.59	59 "	5.69	67 "	5.01	75 "	4.48
52 "	6.46	60 "	5.60	68 "	4.94	76 "	4.42
53 "	6.34	61 "	5.51	69 "	4.87	77 "	4.36
54 "	6.22	62 "	5.42	70 "	4.80	78 "	4.31
55 "	6.11	63 "	5.33	71 "	4.73	79 "	4.25
56 "	6.00	64 "	5.25	72 "	4.67	80 "	4.20
57 "	5.89	65 "	5.17	73 "	4.60	81 "	4.15

TABLE 4

POUNDS OF STEAM PER I. H. P. HOUR FOR VARIOUS MULTIPLES OF "*M*."

(a) For locomotives using saturated steam.

"*M*"=Maximum velocity in miles per hour at full cutoff.
Boiler pressure, 200 lbs.

Velocity	Pounds Steam per I. H. P. Hour		Velocity	Pounds Steam per I. H. P. Hour	
	Simple Locomotive	Compound Locomotive		Simple Locomotive	Compound Locomotive
1.0 M	38.30	25.80	2.9 M.	24.37	21.04
1.1 "	36.46	24.36	3.0 "	24.22	21.21
1.2 "	34.89	23.24	3.2 "	24.00	21.57
1.3 "	33.56	22.35	3.4 "	23.85	21.93
1.4 "	32.41	21.65	3.6 "	23.80	22.27
1.5 "	31.40	21.14	3.8 "	23.80	22.57
1.6 "	30.49	20.77	4.0 "	23.87	22.85
1.7 "	29 67	20.52	4.25 "	24.05	23.22
1.8 "	28.93	20.40	4.50 "	24.24	23.56
1.9 "	28.25	20.40	4.75 "	24.44	23.85
2.0 "	27.62	20.40	5.00 "	24.64	24.15
2.1 "	27.05	20.40	5.5 "	24.98	24.70
2.2 "	26.52	20.40	6.0 "	25.20	
2.3 "	26.06	20.40	6.5 "	25.45	
2.4 "	25.67	20.40	7.0 "	25.60	
2.5 "	25.32	20.47	7.5 "	25.70	
2.6 "	25.02	20.60	8.0 "	25.80	
2.7 "	24.76	20.73	9.0 "	25.90	
2.8 "	24.54	20.88			

For steam per I. H. P. hour for other boiler pressures take the following percentages of values given in table:

160 lb., 103 per cent.
170 lb., 102.1 per cent.
180 lb., 101.3 per cent.
190 lb., 100.6 per cent.
210 lb., 99.5 per cent.
220 lb., 99.2 per cent.

(b) For simple locomotives using superheated steam.

Velocity	Pounds of Steam Per I. H. P. Hour.	Velocity	Pounds of Steam Per I. H. P. Hour.
1.0 M	24.00	2.8 M	18.70
1.1 "	23.58	2.9 M	18.55
1.2 "	23.10	3.0 M	18.40
1.3 "	22.74	3.2 M	18.20
1.4 "	22.28	3.4 M	18.00
1.5 "	21.92	3.6 M	17.79
1.6 "	21.55	3.8 M	17.60
1.7 "	21.20	4.0 M	17.44
1.8 "	20.90	4.25 M	17.26
1.9 "	20.59	4.5 M	17.10
2.0 "	20.32	4.75 M	16.96
2.1 "	20.05	5.0 M	16.86
2.2 "	19.81	5.5 M	16.72
2.3 "	19.60	6.0 M	16.63
2.4 "	19.40	6.5 M	16.62
2.5 "	19.22	7.0 M	16.62
2.6 "	19.02	8.0 M	16.62
2.7 "	18.86		

TABLE 5

PER CENT. CYLINDER TRACTIVE POWER FOR VARIOUS MULTIPLES OF "*M*."

"*M*"=Maximum Velocity in Miles per hour at which Boiler Pressure can be maintained with full cutoff.

(a) For locomotives using saturated steam.

Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.
Start	(Simple) 135.00	106.00	3.6 M	32.40	44.75	6.4 M		23.59
0.5 M	103.00	103.00	3.7 "	31.25	43.56	6.5 "		23.18
1.0 "	100.00	100.00	3.8 "	30.10	42.39	6.6 "		22.79
1.1 "	96.28	95.57	3.9 "	29.14	41.24	6.7 "		22.42
1.2 "	92.55	91.53	4.0 "	28.24	40.10	6.8 "		22.06
1.3 "	88.83	87.83	4.1 "	27.38	39.00	6.9 "		21.71
1.4 "	85.12	84.46	4.2 "	26.56	37.96	7.0 "		21.38
1.5 "	81.40	81.37	4.3 "	25.77	36.97	7.1 "		21.06
1.6 "	77.68	78.55	4.4 "	25.03	36.03	7.2 "		20.75
1.7 "	73.96	75.97	4.5 "	24.34	35.13	7.3 "		20.45
1.8 "	70.25	73.60	4.6 "	23.69	34.26	7.4 "		20.16
1.9 "	66.54	71.41	4.7 "	23.07	33.41	7.5 "		19.88
2.0 "	63.21	69.37	4.8 "	22.48	32.59	7.6 "		19.61
2.1 "	60.20	67.47	4.9 "	21.92	31.82	7.7 "		19.34
2.2 "	57.48	65.67	5.0 "	21.38	31.11	7.8 "		19.08
2.3 "	54.97	63.94	5.1 "	20.87	30.42	7.9 "		18.82
2.4 "	52.68	62.22	5.2 "	20.37	29.75	8.0 "		18.57
2.5 "	50.42	60.55	5.3 "	19.89	29.10	8.1 "		18.33
2.6 "	48.16	58.92	5.4 "	19.43	28.48	8.2 "		18.09
2.7 "	46.08	57.33	5.5 "	18.99	27.87	8.3 "		17.86
2.8 "	44.10	55.78	5.6 "		27.33	8.4 "		17.64
2.9 "	42.29	54.26	5.7 "		26.81	8.5 "		17.43
3.0 "	40.57	52.78	5.8 "		26.30	8.6 "		17.22
3.1 "	38.95	51.33	5.9 "		25.81	8.7 "		17.01
3.2 "	37.42	49.91	6.0 "		25.34	8.8 "		16.82
3.3 "	35.98	48.55	6.1 "		24.88	8.9 "		16.63
3.4 "	34.66	47.24	6.2 "		24.44	9.0 "		16.45
3.5 "	33.53	45.97	6.3 "		24.01			

(b) For simple locomotives using superheated steam.

Velocity	Per Cent	Velocity	Per Cent	Velocity	Per Cent	Velocity	Per Cent
Start	106.00	2.7 M	47.12	4.5 M	31.19	6.3 M	22.90
0.5 M	103.00	2.8 M	45.82	4.6 M	30.61	6.4 M	22.56
1.0 M	100.00	2.9 M	44.61	4.7 M	30.05	6.5 M	22.21
1.1 M	92.42	3.0 M	43.49	4.8 M	29.52	6.6 M	21.89
1.2 M	86.55	3.1 M	42.30	4.9 M	29.00	6.7 M	21.57
1.3 M	81.20	3.2 M	41.21	5.0 M	28.48	6.8 M	21.24
1.4 M	76.95	3.3 M	40.17	5.1 M	27.96	6.9 M	20.92
1.5 M	73.00	3.4 M	39.22	5.2 M	27.47	7.0 M	20.62
1.6 M	69.55	3.5 M	38.30	5.3 M	27.00	7.1 M	20.32
1.7 M	66.60	3.6 M	37.42	5.4 M	26.53	7.2 M	20.07
1.8 M	63.66	3.7 M	36.61	5.5 M	26.10	7.3 M	19.78
1.9 M	61.27	3.8 M	35.89	5.6 N	25.69	7.4 M	19.52
2.0 M	58.96	3.9 M	35.11	5.7 M	25.26	7.5 M	19.26
2.1 M	56.94	4.0 M	34.39	5.8 M	24.86	7.6 M	19.01
2.2 M	55.12	4.1 M	33.72	5.9 M	24.46	7.7 M	18.76
2.3 M	53.26	4.2 M	33.06	6.0 M	24.04	7.8 M	18.52
2.4 M	51.53	4.3 M	32.40	6.1 M	23.66	7.9 M	18.28
2.5 M	49.98	4.4 M	31.79	6.2 M	23.28	8.0 M	18.06
2.6 M	48.50						

TABLE 6

POUNDS TRACTIVE POWER FOR ONE HORSEPOWER AT VARIOUS SPEEDS.

Formula: $\text{One H. P.} = \frac{375}{\text{Velocity in miles per hour}}$

Velocity	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3	125.0	120.97	117.19	113.64	110.29	107.14	104.17	101.35	98.68	96.15
4	93.75	91.46	89.29	87.21	85.23	83.33	81.52	79.79	78.13	76.53
5	75.00	73.53	72.12	70.75	69.44	68.18	66.96	65.79	64.66	63.56
6	62.50	61.48	60.48	59.52	58.59	57.69	56.82	55.97	55.15	54.35
7	53.57	52.82	52.08	51.37	50.68	50.00	49.34	48.70	48.08	47.47
8	46.88	46.30	45.74	45.18	44.64	44.12	43.60	43.10	42.61	42.13
9	41.67	41.21	40.76	40.32	39.89	39.47	39.06	38.66	38.27	37.88
10	37.50	37.13	36.77	36.41	36.06	35.71	35.38	35.05	34.72	34.40
11	34.09	33.78	33.48	33.19	32.89	32.61	32.33	32.05	31.78	31.51
12	31.25	30.99	30.74	30.49	30.24	30.00	29.76	29.53	29.30	29.07
13	28.85	28.63	28.41	28.20	27.99	27.78	27.57	27.37	27.17	26.98
14	26.79	26.60	26.41	26.22	26.04	25.86	25.68	25.51	25.34	25.17
15	25.00	24.83	24.67	24.51	24.35	24.19	24.04	23.88	23.73	23.58
16	23.44	23.29	23.15	23.01	22.87	22.73	22.59	22.46	22.32	22.19
17	22.06	21.93	21.80	21.68	21.55	21.43	21.31	21.19	21.07	20.95
18	20.83	20.72	20.60	20.49	20.38	20.27	20.16	20.05	19.95	19.84
19	19.74	19.63	19.53	19.43	19.33	19.23	19.13	19.03	18.94	18.84
20	18.75	18.66	18.56	18.47	18.38	18.29	18.20	18.12	18.03	17.94
21	17.86	17.77	17.69	17.61	17.52	17.44	17.36	17.28	17.20	17.12
22	17.05	16.97	16.89	16.82	16.74	16.67	16.59	16.52	16.45	16.37
23	16.30	16.23	16.16	16.09	16.03	15.96	15.89	15.82	15.76	15.69
24	15.63	15.56	15.50	15.43	15.37	15.31	15.24	15.18	15.12	15.06
25	15.00	14.94	14.88	14.82	14.76	14.71	14.65	14.59	14.53	14.48
26	14.42	14.37	14.31	14.26	14.20	14.15	14.10	14.04	13.99	13.94
27	13.89	13.84	13.79	13.74	13.68	13.63	13.59	13.54	13.49	13.44
28	13.39	13.35	13.30	13.25	13.20	13.16	13.11	13.07	13.02	12.98
29	12.93	12.89	12.84	12.80	12.76	12.71	12.67	12.63	12.58	12.54
30	12.50	12.46	12.42	12.38	12.34	12.30	12.26	12.22	12.18	12.14
31	12.10	12.06	12.02	11.98	11.94	11.90	11.87	11.83	11.79	11.76
32	11.72	11.68	11.65	11.61	11.57	11.54	11.50	11.47	11.43	11.40
33	11.36	11.33	11.30	11.26	11.23	11.19	11.16	11.13	11.09	11.06
34	11.03	11.00	10.96	10.93	10.90	10.87	10.84	10.81	10.78	10.74
35	10.71	10.68	10.65	10.62	10.59	10.56	10.53	10.50	10.47	10.44
36	10.42	10.39	10.36	10.33	10.30	10.27	10.24	10.21	10.18	10.16

For intermediate velocities, values per horsepower can be found by interpolation.

TABLE 7

Locomotive Resistances.

Ⓐ Cylinder to Rim of Drivers:
Total Pounds $R=18.7T+80N$.
T=Tons Weight on Drivers.
N=Number Driving Axles.

Ⓑ Engine and Tender Trucks:
Total Pounds $R=2.6T+20N$.
T=Tons Weight on Engine and Tender Trucks.
N=Number of Truck Axles.

Ⓒ Head End or "Air" Resistance.
$R=.002V^2A$;......
V=Velocity in Miles per Hour.
A=Area (Average for Locomotives, 125 sq. ft.).

Total $R=0.25V^2$.

Air Resistance (C) for Various Velocities.

Velocity	R	Velocity	R	Velocity	R	Velocity	R
1	0.25	11	30	21	110	31	240
2	1.00	12	36	22	121	32	256
3	2.25	13	42	23	132	33	272
4	4.00	14	49	24	144	34	289
5	6.25	15	56	25	156	35	306
6	9.00	16	64	26	169	36	324
7	12.25	17	72	27	182	37	342
8	16.00	18	81	28	196	38	361
9	20.25	19	90	29	210	39	380
10	25.00	20	100	30	225	40	400

Drawbar pull on level tangent equals the cylinder Tractive Power less the sum of Engine Resistances.

At Low Speeds the adhesion of drivers should be considered and available drawbar pull should never be estimated greater than 30 per cent. of Weight on Drivers at starting with use of sand, 25 per cent. of Weight on Drivers at running speeds.

[8]TRAIN RESISTANCE.

(1) Dynamometer tests to be of the greatest value should show the following:

(a) Dynamometer record (graphical) showing drawbar pull to nearest ten pounds, with horizontal scale not less than 400 feet to one inch and in special cases a larger scale.

(b) Speed record to nearest tenth of mile per hour (graphical).

(c) Key to record mile posts.

(d) Condition of track surface and gage (graphical).

(e) Steam pressure of boiler (graphical).

(f) Train line air pressure (graphical).

(g) Time record (graphical).

(Speed record may be independent record, and in this case time record is desirable.)

(h) Coal consumption (record of shovels of coal as used) (worked by hand in engine).

Requisite data to be taken:

TRACK.

(i) Office profile and alinement connecting with mile posts (so as to connect with (3).

(j) Section of rail.

(k) Condition of rail.

(l) Number of ties to rail (and rail length).

(m) Kind and quantity of ballast.

LOCOMOTIVE.

(n) Type (wheel arrangement, whether simple or compound and dimensions of locomotive).

(o) Total weight and weight on drivers.

CARS.

(p) Record of length, initial, number, class of each car of train; also weight empty and weight loaded.

(q) Kind of truck.

(r) Condition of car.

---

[8] Adopted, Vol. 11, Part 1, 1911, pp. 647-666, 715-731.

WEATHER.

(s) Temperature.

(t) Direction of force of wind and direction of train.

(u) State of weather (rainy or clear).

(2) Numerous tests demonstrate that there is no absolute value for train resistance. For practical purposes freight train resistance can be considered constant between velocities of 7 and 35 miles per hour.

(3) The following formulas are practicable where train has been in motion at least fifteen minutes.

(a) Assuming that

A Rating is used at temperatures of 35 degrees Fahrenheit or higher,

B Rating is used at temperatures between 20 and 35 degrees Fahrenheit,

C Rating is used at temperatures between 0 and 20 degrees Fahrenheit, and

D Rating is used at temperatures below 0 degrees Fahrenheit, the following formulas are practical:

A Rating: $R = 2.2\ T + 122\ C$ (on level grade)
B Rating: $R = 2.2\ T + 122\ C$ (on level grade)
C Rating: $R = 4.0\ T + 153\ C$ (on level grade)
D Rating: $R = 5.4\ T + 171\ C$ (on level grade)

when $R =$ total resistance of train in pounds.
$T =$ tonnage of train in tons of 2000 pounds.
$C =$ the number of cars in the train.

(4) (a) Compensate .03 per degree:

When the length of curve is less than half the length of the longest train.

When a curve occurs within the first 20 feet of rise of a grade.

When curvature is in no sense limiting.

(b) Compensate .035 per degree:

When curves are between one-half and three-quarters as long as the longest train.

When the curve occurs between 20 feet and 40 feet of rise from the bottom of the grade.

(c) Compensate .04 per degree:

Where the curve is habitually operated at low speed.

Where the length of the curve is longer than three-quarters of the length of the longest train.

Where elevation is excessive for freight trains.

At all places where curvature is likely to be limiting.

(d) Compensate .05 per degree wherever the loss of elevation can be spared.

(5) Condition of roadway maintenance has a great effect on train resistance.

(6) Condition and design of equipment has a great effect on train resistance.

PERCENTAGE OF ADJUSTED RATING "B," "C" AND "D"
"A" RATING TAKEN AS 100%.

Per Cent. Grade	Adjustment	"B"	"C"	"D"
0.1	29	84	70	57
0.15	23	87	74	62
0.2	20	89	78	66
0.25	17	90	80	69
0.3	15	91	82	72
0.35	13	92	84	74
0.4	12	93	85	76
0.45	11	93	86	78
0.5	10	94	87	79
0.55	9	94	88	81
0.6	9	95	89	82
0.65	9	95	89	83
0.7	8	95	90	84
0.75	7	96	91	84
0.8	7	96	91	85
0.85	6	96	91	86
0.9	6	96	92	86
1.0	5	97	93	87
1.1	5	97	93	88
1.2	5	97	93	89
1.3	4	97	94	90
1.4	4	97	94	91
1.5	4	98	95	91
1.6	4	98	95	92
1.7	3	98	95	92
1.8	3	98	96	93
1.9	3	98	96	93
2.0	3	98	96	93
2.1	3	98	96	93
2.2	3	98	96	94
2.3	2	98	96	94
2.4	2	98	96	94
2.5	2	99	97	94
2.6	2	99	97	94
2.7	2	99	97	95
2.8	2	99	97	95
2.9	2	99	97	95
3.0	2	99	97	95

(7) Resistance of individual cars of same weight but of different type shows considerable variation. Sufficient data are not yet available to determine just how much the difference is.

(8) Starting resistance varies from 10 to 40 lbs. per ton, depending on loading, temperature and character of maintenance of roadway and equipment.

[4]CURVATURE.

(1) A straight line is the ideal alinement.

(2) The justifiable expenditure to eliminate one degree of central angle in the alinement of roadway depends largely on the number of daily trains and the cost per train per mile.

(3) As a general rule it is good practice to spend more money to take out one degree of central angle where the radius is small, requiring the maximum elevation of the outer rail, than where the radius is large, requiring less elevation.

(4) As a general rule, it is justifiable to spend more money to take out one degree of central angle where train runs at a high rate of speed than where the speed is low.

[5] CURVE RESISTANCE—FREIGHT CARS.

Tests made on the Canadian Pacific Railway at Winnipeg on wheels of freight cars running on curved and straight track demonstrate that:

(1) All outer wheels of railway cars exert a pressure against the outer rail when rounding a curve.

(2) The cause of this pressure is the tendency of a cylindrical body to rotate in a straight line at right angles to the axis of rotation.

(3) There is never any skidding of either wheels of the leading axle of a truck unless it is a forward skidding of both wheels caused by the resistance to rotation being great enough to cause a slight retardation to rotation which results in an apparent forward skidding.

(4) There is no skidding of the outer wheel of a rear axle, and in general any skidding that does take place is on the inner wheel of the rear axle.

These tests also suggest that as the flange is pressed against the rail, the concave curve at the base of the flange increases the effective diameter of the outer wheel so as to prevent skidding of the wheels of the front axle and to minimize, if not entirely prevent, skidding of either wheel in the rear axle.

(Tests did not include engine driving wheels.)

---

[4] Adopted, Vol. 11, Part 1, 1911, pp. 666-669, 732, 733.

[5] Adopted, Vol. 21, 1920, pp. 305, 1382.

COMMITTEE XVII.

WOOD PRESERVATION.

[1] GENERAL REQUIREMENTS.

(1) Creosote oil and zinc-chloride are effective wood preservatives when properly applied and when used under proper conditions.

(2) Accurate records should be kept in order to form proper conclusions as to the merit of different methods and processes.

(3) Preserved wood may be destroyed by mechanical action long before it is decayed, and therefore should be protected by economical devices when the mechanical life limits the life of the tie.

(4) There should be a standard temperature at which creosote oil is measured. The temperature of 100 degrees Fahrenheit is recommended.

(5) It is essential that timber should be properly grouped in order that a successful treatment may be obtained. The species, in proportion of heartwood and sapwood, condition of the timber with respect to its moisture content and the wood structure, will in general determine this grouping.

(6) It is desirable to air-season timber in order to prepare it for treatment. Most woods can be best treated after being air-seasoned.

(7) Chemicals used should be tested for purity from time to time. Either the chemists for the Company will do this themselves or indicate some simple tests which may be applied by operatives at the works.

(8) In operating with zinc-chloride, the strength of the solution should be varied from time to time to conform to the kind and condition of the ties, so as to inject the required quantities. But in no case should the strength of the solution exceed 5 per cent.

(9) It is better to inject quantities of the chemicals in excess of the requirements than to skimp the treatment in any way.

(10) Daily reports should be kept at the works, and duplicates sent to the general office, if desired, in order to check the operation.

(11) Ties treated with zinc-chloride should dry for some little time (to harden the outer surface) before they are put in the tracks. This is preferably done in piles, arranged to induce drying without checking as evaporation takes place.

---

[1] Adopted, Vol. 10, 1909, pp. 629-631, 669-676; Vol. 11, Part 2, 1910, pp. 737, 761, 859.

(12) For best results it is recommended that certain sections of track be selected on each railroad for the purpose of making accurate tests covering the life of treated and untreated ties of various kinds of timber and under various treatments, and that an accurate record be kept of the life of all ties in these test sections of track in order to be able hereafter to improve on the treatment. All ties inserted in such test sections shall be marked with dating nails, and, if necessary, with their identification marks.

(13) In order to judge of the penetration of the oil, borings should be made with an augur, ¾ to 1 inch in diameter, in not less than six ties in each cylinder load. The holes should be plugged with creosoted turned plugs of diameter 1/16-inch larger than the holes.

(14) Bridge material intended for treatment should be framed, as far as possible, before timbers are placed in the treating cylinder. This includes the boring of the necessary holes.

[2] GROUPING OF TIMBERS FOR ANTISEPTIC TREATMENT.

(1) Ties of approximately the same period of seasoning should be grouped together for treatment; green ties should never be mixed with seasoned ones.

(2) Pine ties should be separated on the basis of heartwood and sapwood; it would also be advisable in some cases to group hardwoods on the same basis, but it is not generally practical to do so.

(3) Grouping on the basis of species and families, as, for example, red oaks, pine, beech, etc., if a further division into heartwood classes is made with pine, is usually a satisfactory practice. From this it follows that red oak, beech, longleaf pine, loblolly pine and gum should be treated separately. Birch and hard maples and certain other combinations, depending on the locality, can be grouped together to advantage.

(4) The separation in the yard, on the basis the ties are to be grouped for treatment, is an essential and economical practice.

[3] SPECIFICATIONS FOR GRADE 1 CREOSOTE OIL.

The oil shall be distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent. of water.

---

[2] Adopted, Vol. 13, 1912, pp. 864, 1040-1041.

[3] Adopted, Vol. 20, 1919, pp. 122, 838; Vol. 21, 1920, pp. 325, 1384.

2. It shall contain not more than 0.5 per cent. of matter insoluble in benzol.

3. The specifice gravity of the oil at 38°/15.5° C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 5 per cent.
Up to 235 degrees Centigrade not more than 25 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38°/15.5° C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38°/15.5° C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent., shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent. coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

In addition to the oil conforming to the above standard specification, the two grades specified below may be used when the higher grade oil cannot be procured:

Specifications for Grade 2 Creosote Oil.

The oil shall be a distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent. of water.

2. It shall contain not more than 0.5 per cent. of matter insoluble in benzol.

3. The specific gravity of the oil at 38°/15.5° C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 8 per cent.
Up to 235 degrees Centigrade not more than 35 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38°/15.5° C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38°/15.5° C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent., shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent. coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

Specifications for Grade 3 Creosote Oil.

The oil shall be a distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent. of water.

2. It shall contain not more than 0.5 per cent. of matter insoluble in benzol.

3. The specific gravity of the oil at 38°/15.5° C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 10 per cent.
Up to 235 degrees Centigrade not more than 40 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38°/15.5° C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38°/15.5° C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent., shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent. coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

It is urged that when Grades 2 or 3 are used, consideration be given to the injection of a greater quantity of creosote oil per cubic yard.

[4] SPECIFICATIONS FOR CREOSOTE-COAL-TAR SOLUTION.

The oil shall be a coal-tar product, of which at least 80 per cent. shall be a distillate of coal-gas or coke-oven tar, and the remainder shall be refined or filtered coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent. water.

2. It shall contain not more than 2 per cent. of matter insoluble in benzol.

3. The specific gravity of the oil at 38 degrees / 15.5 degrees Centigrade shall not be less than 1.05 nor more than 1.12.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 5 per cent.
Up to 235 degrees Centigrade not more than 25 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than 1.03 at 38°/15.5° C.

---

[4] Adopted, Vol. 20, 1919, pp. 124, 839.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38°/15.5° C.

6. The residue above 355 degrees Centigrade, if it exceeds 26 per cent., shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 6 per cent. coke residue.

8. The foregoing tests shall be made in accordance with the recommended methods of the American Railway Engineering Association.

[5] PRECAUTIONS TO BE FOLLOWED IN THE PURCHASE AND USE OF THE CREOSOTE-COAL-TAR SOLUTION.

1. The specifications for a creosote-coal-tar solution is submitted for the guidance of those desiring to use the coal tar addition to creosote.

2. There should be a distinct understanding between all concerned that a mixture is specified and used.

3. The refined coal-tar used shall be subject to inspection or analysis by the railway company at any time, such examination to be permitted upon request prior to the mixing of the solution.

4. In case the railway company makes its own solution of coal-tar and creosote, using crude tar for this purpose, it shall specify clearly as to the quality of the tar. Only low carbon coal-tar should be used, the amount of free carbon not to exceed 5 per cent.

5. The coal-tar may be added to the creosote at treating plants when suitable facilities for properly mixing the solutions are available, otherwise the solution should be mixed by the manufacturer, but subject to the inspection or supervision of the railway company. The coal-tar and creosote should be thoroughly mixed at a temperature of approximately 180 degrees Fahrenheit before being applied to timber. The mixing should be done in tanks other than the regular working tanks, and the tanks containing the mixture should be heated and agitated thoroughly each time before any oil is transferred to the working tanks.

6. In treating with the mixture the temperature of the solution in the cylinder should not be less than 180 degrees Fahrenheit.

[6] THE USE OF COAL TAR IN CREOSOTE.

(1) Wherever possible only Grade 1 Coal Tar Creosote should be used, and under no circumstances should coal tar be added to creosote of this grade.

---

[5] Adopted, Vol. 20, 1919, pp. 125, 840.

[6] Adopted, Vol. 15, pp. 632, 1093, 1094.

[7]SPECIFICATIONS FOR CREOSOTE OIL ANALYSES.

(1) WATER.

Apparatus.

A vertical, cylindrical copper still, with removable flanged top, and yoke, of the form and approximate dimensions shown in Fig. 1, shall be used.

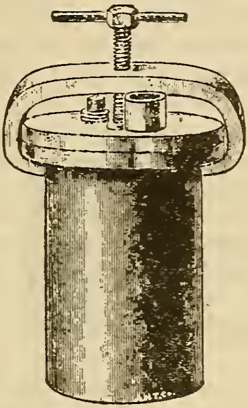


FIG. 1.—COPPER STILL.

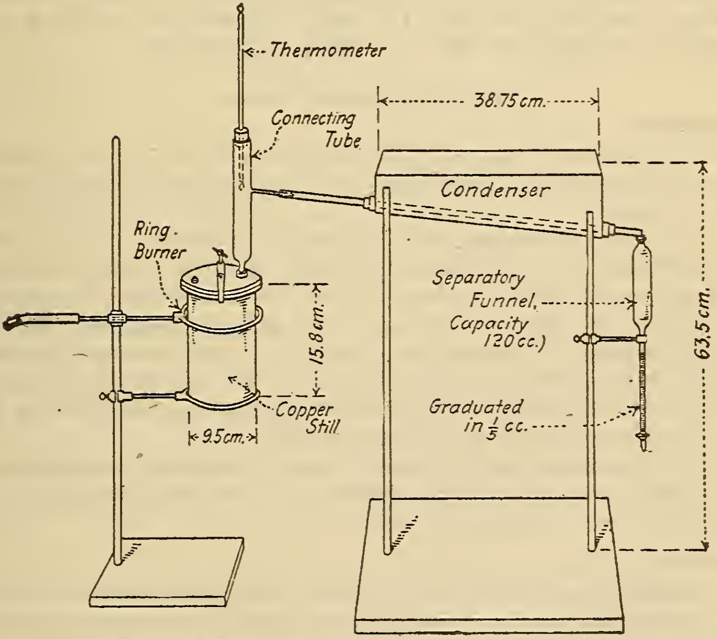


FIG. 2—ASSEMBLED APPARATUS FOR WATER TEST.

---

[7]Adopted, Vol. 18, 1917, pp. 1262, 1577; Vol. 20, 1919, pp. 127, 840.

Method.

When any measurable amount of water is present in the distillate below 210 degrees, on testing in accordance with Section 4, Distillation, the oil and water in this fraction shall be separated, if possible, and measured separately. If more than 2 per cent. of water is present, or if the water is apparently present to an extent in excess of 2 per cent., but an accurate separation is impossible, the percentage of water present shall be determined by the following method, and the water-free oil so obtained shall be used in distillation test, as described under Section 4.

Measure 200 cc. of oil in graduated cylinder, and pour into copper still (Figs. 1 and 2), allowing the cylinder to drain into the still for several minutes. Attach lid and clamp, using a paper gasket slightly wet with oil around the flange of the still. Apply heat by means of the ring burner, which should be placed just above the level of the oil in the still at the beginning of the test, and gradually lowered when most of the water has distilled over. Continue the distillation until the vapor temperature indicated by the thermometer with the bulb opposite the offtake of the connecting tube reaches 205 degrees Centigrade. Collect distillate in separatory funnel.

When the distillation is completed, and a clear separation of water and oil in the funnel has taken place, the water is read by volume and drawn off, and whatever light oil has distilled over with the water is then returned to the oil in the still. The dehydrated oil from the still is then taken for distillation, described in Section 4, Distillation.

(2) Insoluble in Benzol.

Apparatus.

(a) Extractor may be of the form shown in Fig. 3, or any similar form in which the oil is subjected to direct washing by the boiling vapors of the solvent.

(b) Filtering medium may be either two thicknesses of S. & S. No. 575 or Whatman No. 5 hardened filter paper, 15 cm. in diameter, arranged in cup-shape by folding symmetrically; or alundum thimbles, flat bottom, 30x80 R.A. 98. If filter papers are used, prior to using they shall be soaked in benzol to remove grease, dried in a steam oven and kept in a desiccator until ready to be used. The filter-paper cup may be suspended in the extractor flask by a wire basket hung from two small hooks on the under surface of the metal cover of the flash.

If the alundum thimble is used, it may be supported by making two perforations in the top of the thimble, and suspending from the cover by German silver or platinum wires.

Method.

Weigh 10 grams of dry oil in 100 cc. beaker. Add about 50 cc. of pure benzol, and transfer at once to the filter cup. The filter cup or thimble is previously weighed, and the paper cup shall always be kept in a weighing bottle until ready for use. Wash out the beaker with benzol, passing all washings through the filter cup, and place the latter at once in the extraction apparatus.

Extractor shall contain a suitable quantity of pure benzol. Sufficient heat to boil the solvent shall be provided by means of an electric heater or a steam bath.

Continue the extraction until the descending solvent is practically colorless, and remove the filter cup and dry in steam oven until all solvent is driven off; cool in desiccator and weigh. The balance used for this purpose should be accurate to within 0.5 mg.

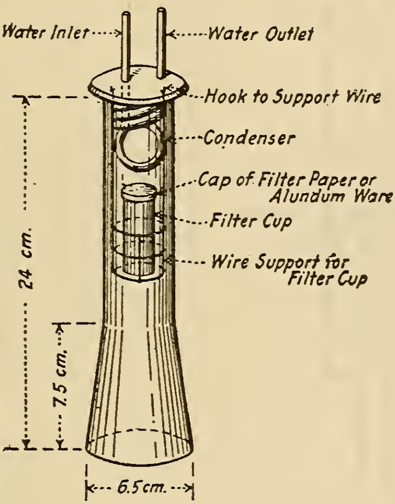


Fig. 3.—Extraction Flask.

(3) Specific Gravity.

Apparatus.

(a) Hydrometer shall be of the form and dimensions shown in Fig. 4. It shall be standardized at 15.5 degrees Centigrade. A set of two with ranges 1.00 to 1.08 and 1.07 to 1.15 will suffice.

(b) Cylinder shall be of the form and dimensions shown in Fig. 5.

(c) If a very accurate method is desired, the specific gravity may be determined by means of a pycnometer or specific gravity bottle, as shown in Fig. 6, having a capacity of at least 25 cubic centimeters.

Method.

(a) The oil shall be brought to a temperature of 38 degrees Centigrade (100 degrees Fahrenheit), and the determination shall be made at that temperature unless the oil is not entirely liquid at 38 degrees Centigrade. In case the oil requires to be brought to a higher temperature than 38 degrees in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by adding 0.0008 to the observed specific gravity for each degree Centigrade above 38 degrees Centigrade at which the test is made. This correction does not apply with equal accuracy to all oils, but serious error, due to its use, will be avoided if the foregoing precaution is observed, with respect to avoiding unnecessarily high temperature.

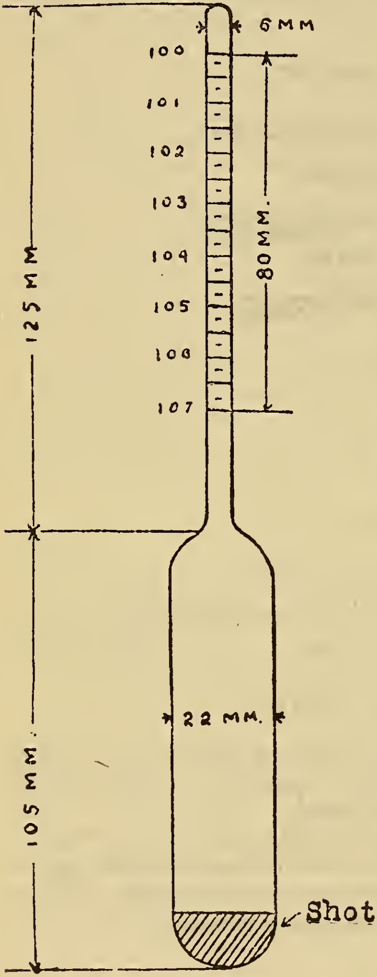


FIG. 4. HYDROMETER.

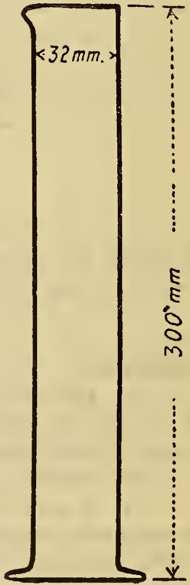


FIG. 5. SPECIFIC GRAVITY CYLINDER.

Before taking the specific gravity, the oil in the cylinder should be stirred thoroughly with the glass rod, and this rod, when withdrawn from the liquid, should show no solid particles at the instant of withdrawal. Care should be taken that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken, and that the oil surface is free from froth and bubbles.

(b) Weigh the pycnometer empty, then fill with recently distilled water and weigh at 38 degrees Centigrade. Empty the pycnometer and then fill with water-free oil at 38 degrees Centigrade, and weigh. The specific gravity 38/°15.5°C. is then calculated as below:

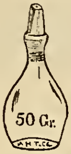


Fig. 6.—Pycnometer.

The expression "38 degrees / 15.5 degrees Centigrade" means specific gravity taken at 38 degrees Centigrade compared with water at 15.5 degrees Centigrade. This cannot be determined directly. The specific gravity is first determined at 38 degrees Centigrade compared with water at 38 degrees Centigrade, and this determination represents the relation of the weight of a volume of oil at 38 degrees Centigrade to the weight of an equal volume of water at the same temperature. The relation of an equal volume of water at 15.5 degrees Centigrade is obtained by multiplying the former figure by .99385, the density of water at 38 degrees Centigrade compared to water at 15.5 degrees Centigrade.

From the foregoing it will be readily seen that it is incorrect to calculate the specific gravity at 38°/15.5° C., by dividing the weight of oil taken at 38 degrees Centigrade by the weight of water taken at 15.5 degrees Centigrade. An example is given herewith of the correct and incorrect methods of calculating; where the weight of a specific gravity bottle is 23.7531, the weight of the bottle filled with water up to the mark at 15.5 degrees Centigrade is 78.3600; the weight of the bottle plus water at 38 degrees Centigrade is 78.1128; the weight of the bottle filled with oil at 38 degrees Centigrade is 80.2755. The correct calculation, therefore, would be as follows:

Specific gravity at 38°/15.5° C.—

$$\frac{80.2755 - 23.7531}{78.1128 - 23.7531} - 1.0398$$

Corrected to 38°/15.5° C.—

$$1.0398 \times \frac{.99299 \text{ (D. water 38 degrees)}}{.99913 \text{ (D. water 15 degrees)}}$$

The incorrect method of calculation is as follows:

$$\frac{80.2755 - 23.7531}{78.3600 - 23.7531} - 1.0351.$$

(4) Distillation.

Apparatus.

(a) Retort shall be a tabulated glass retort of the usual form with a capacity of 250 to 290 cc. The capacity shall be measured by placing the retort with the bottom of the bulb and the end of the offtake in the same horizontal plane, and pouring water into the bulb through the tubulature until it overflows the offtake. The amount remaining in the bulb shall be considered its capacity (Fig. 8).

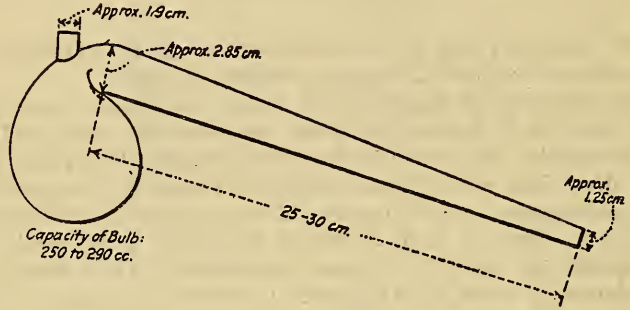


Fig. 7.—Retort for Distillation Test.

(b) Condenser tube of any suitable form of glass may be used; a convenient one is shown in Fig. 8.

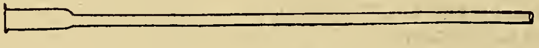


Fig. 8.—Condenser Tube.

(c) Shield of asbestos as shown in Fig. 9 shall be used to protect the retort from air currents, and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

(d) Receivers (Erlenmeyer flask) of 50 to 100 cc. capacity are most convenient form.

(e) Thermometer shall be made of resistance glass of a quality equivalent to suitable grades of Jena or Corning make. It shall be thoroughly annealed. It shall be filled above the mercury with inert gas which will not act chemically on or contaminate the mercury. The pressure of the gas shall be sufficient to prevent separation of the mercury column at all temperatures of the scale. There shall be a reservoir above the final graduation large enough so that the pressure will not become excessive at the highest temperature.

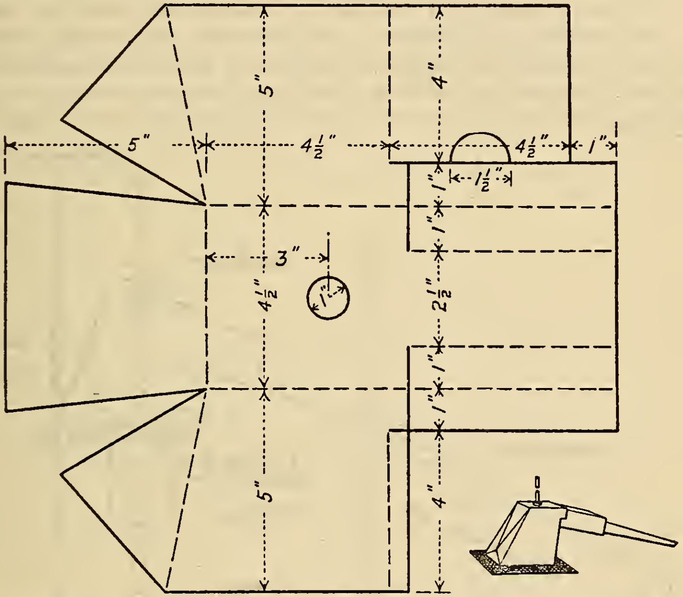


Fig. 9—Asbestos Shield.

The thermometer shall be finished at the top with a small glass ring or button suitable for attaching a tag. Each thermometer shall have for identification the maker's name, a serial number and the letters "A. S. T. M. Distillation."

The thermometer shall be graduated from 0 to 400 degrees Centigrade at intervals of 1 degree Centigrade. Every fifth graduation shall be longer than the intermediate ones, and every tenth graduation beginning at zero shall be numbered. The graduation marks and numbers shall be clear cut and distinct.

The thermometer shall conform to the following dimensions:

Total length, mm., 385 maximum.

Diameter of stem, mm., 7; tolerance, 0.5.

Diameter of bulb, mm., 5 minimum, and shall not exceed that of the stem.

Length of bulb, mm., 12.5; tolerance, 2.5.

Distance 0 degrees to bottom of bulb, 30; tolerance, 5.

Distance 0 degrees to 400 degrees Centigrade, 295; tolerance, 10.

The accuracy of the thermometer when delivered to the purchaser shall be such that when tested at full immersion the maximum error from 0 degrees to 200 degrees Centigrade shall not exceed 0.5 degrees; 200 degrees to 300 degrees Centigrade it shall not exceed 1 degree Centigrade; 300 degrees to 375 degrees Centigrade, it shall not exceed 1.5 degrees Centigrade.

The sensitiveness of the thermometer shall be such that when cooled to a temperature of 74 degrees Centigrade below the boiling point of water at the barometric pressure at the time of the test and plunged into free flow of steam, the meniscus shall pass the point 10 degrees Centigrade below the boiling point of water in not more than six seconds.

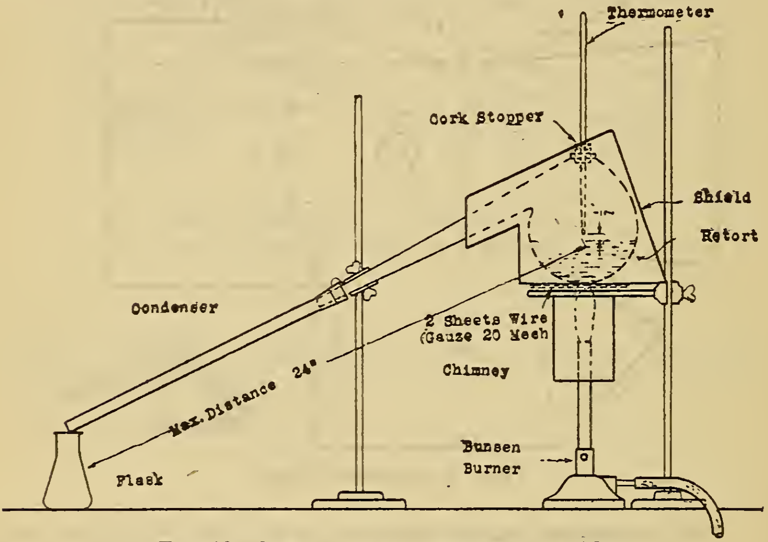


Fig. 10.—Distillation Apparatus Set Up.

The retort shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 6 in. square. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the tubulature with the bottom of the bulb ½-inch from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a vertical rule graduated in divisions not exceeding 1/16-in. back of the retort when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb. The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 24 nor less than 20 in. The burner shall be protected from draughts by a suitable shield or chimney (Fig. 10).

Method.

Exactly 100 grams of oil shall be weighed into the retorts, the apparatus assembled, and heat applied. The distillation shall be conducted at the rate of at least one drop and not more than two drops per second, and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the following points: 210 degrees, 235 degress, 270 degrees, 315 degrees, and 355 degrees Centigrade.

The receivers shall be changed as the mercury passes the dividing temperature for each fraction. When the temperature reaches 355 degrees, the flame shall be removed from the retort, and any oil which has condensed in the offtake shall be drained in the 355-degree fraction.

The residue shall remain in the retort with the cork and the thermometer in position until no vapors are visible; it shall then be weighed. If the residue is to be further tested it shall then be poured directly into the brass collar used in the float test or into a tin box and covered and allowed to cool to air temperature. If the residue becomes so cool that it cannot be poured readily from the retort, it shall be re-heated by holding the bulb of the retort in hot water or steam, and not by the application of flame.

For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

When any measurable amount of water is present in the distillate, it shall be separated as nearly as possible and reported separately, all results being calculated on a basis of dry oil. When more than 2 per cent. of water is present, water-free oil shall be obtained by separately distilling a larger quantity of oil, returning to the oil any oil carried over with the water, and using dried oil for final distillation. (See Section 1, Water.)

(5) Specific Gravity of Fractions.

As specific gravity is an absolute physical determination, any recognized method which can be applied to the qnantity and quality of material at hand to be tested must be considered satisfactory. The following methods are recommended by the Committee as convenient and accurate means for the relatively small amounts of oil available in determining gravity of fractions to be tested.

Liquid Fractions.

Apparatus.

Westphal balance.

Method.

If the fraction to be tested is liquid at a temperature not exceeding 60 degrees Centigrade, the Westphal balance can be used with convenience and rapidity. A special type of Westphal balance is obtainable, designed for testing very small quantities. However, the ordinary type Westphal balance can be adapted to testing small fractions by the use of a special plummet. This can be readily made in the laboratory from a piece of ordinary glass tubing 7 mm., outside diameter, sealed at the end, and melting into the glass where sealed a short platinum wire.

After cooling place 9 to 10 grams of mercury in the tube, making a column 35 to 40 mm. high. Seal off the tube within 20 mm. of the top of the mercury column with blowpipe flame. The plummet shall have a length of about 55 to 60 mm. over all, and should weigh between 10 and 12 grams.

Solid and Semi-Solid Fractions.

Methods.

Special platinum or nickel pan as shown in Fig. 11.

For the determination of fractions that are solid and semi-solid and cannot readily be liquefied at a temperature not exceeding 60 degrees Centigrade, a weighing pan constructed of platinum or nickel (Fig. 11) may be used.

A pan of convenient dimensions is 20 mm. diameter at the base and 25 mm. diameter at the top, and about 12 mm. deep. It is made of platinum and supported by three platinum wires 1 mm. in diameter, and has a total weight of about 7 grams.

Solid or semi-solid fractions of oil can be rapidly and accurately tested in this apparatus by the usual method of weighing in air and in water. The usual precaution, of igniting the pan before use, avoiding the enclosure of air or water in the sample, should be observed.

Note.—The method for liquid fractions is usually applicable to the fractions 235 to 315 degrees Centigrade and the method for solid and semi-solid fractions to the fraction 315 to 355 degrees Centigrade.

(6) Float Test

Apparatus.

(a) Float or Saucer.—The float or saucer shall be made of aluminum, and shall be of the form and dimensions shown in Fig. 12.

(b) Conical Collar.—The conical collar shall be made of brass, and shall be of the form and dimensions shown in Fig. 13.

Float Test Residue.

Place the brass collar with the small end on the brass plate, which has been previously amalgamated with mercury by first rubbing it with dilute solution of mercuric chloride or nitrate and then with mercury. Pour the residue to be tested into the collar direct from the retort, as described in part 4 on "Distillation," under Specification for Creosote Oil Analysis (see page 1265, Vol. 18), or heat it in a tin box on water or steam bath, not by direct application of flame, and then pour into the collar in any convenient way, until slightly more than level with the top. The surplus may be removed after the material has cooled to room temperature, by means of spatula or steel knife which has been slightly heated. Then place the collar and plate in one of the tin cups containing

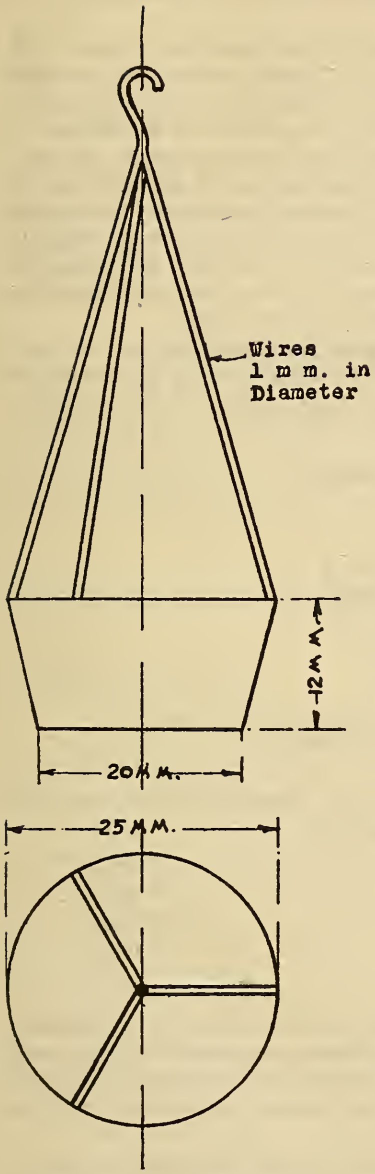


FIG. 11.—WEIGHING PAN.

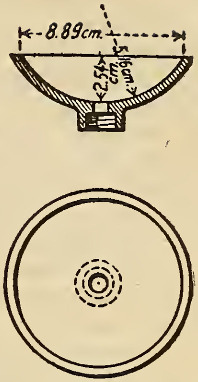


FIG. 12—FLOAT OR SAUCER.

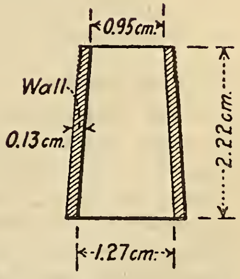


FIG. 13—CONICAL COLLAR

ice water maintained at 5 degrees Centigrade, and leave in this bath for at least 15 minutes.

Meanwhile, fill the other cup about three-fourths full of water and place on the tripod; heat the water to any desired temperature at which the test is to be made. This temperature should be accurately maintained, and should at no time throughout the entire test be allowed to vary more than 0.5 degrees Centigrade from the temperature specified.

After the material to be tested has been kept in the ice water for at least 15 minutes and not more than 30 minutes, remove the collar with its contents from the plate and screw into the aluminum float, which is then immediately floated in the warm bath. As the plug of residue becomes warm and fluid, it is forced upward and out of the collar, until the water gains entrance to the saucer and causes it to sink.

The time in seconds between placing the apparatus on the water and when the water breaks through the residue shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

(7) COKE RESIDUE.

Apparatus.

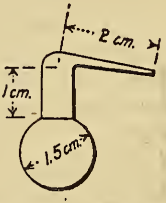


FIG. 14—COKE BULB.

Bulb.—The bulb shall be of hard glass, shown in Fig. 14, and shall have the following approximate dimensions:

Diameter of bulb	15 mm.
Length of vertical neck	10 mm.
Length of horizontal neck	20 mm.
Diameter of orifice	1 mm.

Coke Test Residue.

Warm the bulb slightly to drive off all moisture, cool in a desiccator, and weigh. Again heat the bulb by placing it momentarily in an open Bunsen flame and place the tubular underneath the surface of the oil to be tested and allow the bulb to cool until sufficient oil is sucked in to fill the bulb about two-thirds full.

Any globules of oil sticking to the inside of the tubular should be drawn into the bulb by shaking or expelled by slightly heating it, and the outer surface should be carefully wiped off and the bulb reweighed. This procedure will give about 1 gr. of oil.

Cut a strip of thin asbestos paper about ¼-in. wide and about 1 in.

long, place it around the neck of the bulb and catch the two free ends close up to the neck with a pair of crucible tongs. The oil should then be distilled off as in making ordinary oil distillation, starting with a very low flame and conducting the distillation as fast as can be maintained without spurting.

When the oil vapors cease to come over, the heat should be increased. The bulb should be held in the highest heat of a Bunsen flame until the evolution of gas ceases, and any carbon sticking to the outside of the tubular is completely burned off. The bulb should then be cooled in a desiccator and weighed and the percentage of coke residue calculated to water-free oil.

[8] SPECIFICATION FOR ZINC-CHLORIDE.

The zinc-chloride used shall be acid-free and shall not contain more than 0.1 per cent. iron. Dry zinc-chloride shall contain at least 94 per cent. soluble zinc-chloride, and in any solution specified the percentage of zinc-chloride specified shall be the amount of soluble zinc-chloride required.

[9] SPECIFICATIONS FOR PRESERVATIVE TREATMENTS OF WOOD.

General Requirements.

1. The General Requirements apply to each of the treatments.

2. If used in specifications for the purchase of treated material, these General Requirements should be followed by the specification for the particular treatment desired.

3. Material should not be treated until seasoned. If it arrives at the treating plant in a seasoned condition ready to treat, it may be loaded direct from the cars to the trams; otherwise, it shall be stacked. If ties, they shall be stacked in layers of 1 or 2 and 7 to 10, depending on the width of the ties; if piles or lumber, they shall be stacked to insure even and proper seasoning—with alleys at least 3 feet wide between rows of stacks extending between tracks, and at least 6 inches off the ground on treated sills. The space under and between the rows of stocks at all times should be kept free of rotting wood, weeds or rubbish. The yard should be so drained that no water can stand under the stacks, or in their immediate vicinity.

4. Since the seasoning varies with the latitude, time of year, the exposure and peculiarities of the season, it is essential to establish by experiment the seasoning period usually required to enable each class of timber to best receive treatment. Material piled for seasoning should be closely

---

[8] Adopted. Vol. 21, 1920, pp. 328, 1385.
[9] Adopted, Vol. 21, 1920, pp. 325-334, 1385.

watched, and not allowed to overseason or to deteriorate. No material should be treated which does not conform to the requirements of the specifications as to shakes, checks, soundness, etc. Material which shows signs of checking should be provided with "S" irons, bolts, or other devices, in order to prevent, during or after treatment, further checking that would be liable to render it worthless.

5. Where ties are to be adzed or bored for subsequent insertion of spikes, or application of tie plates, such adzing and boring should in all cases be done before treatment.

Zinc Chloride.

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent. iron. Dry zinc-chloride shall contain at least 94 per cent. soluble zinc chloride, and in any solution purchased the precentage of zinc chloride specified shall be the amount of soluble zinc chloride required.

3. The material shall retain an average of 0.5 lb. of dry zinc chloride per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent. nor more than 110 per cent. of this quantity.

4. The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent. and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory. For example: With red oak the strength shall not exceed 4 per cent., and the volume injected shall be not less than 20 per cent., while with pine having a large percentage of sapwood it shall not exceed 2 per cent., and the volume injected shall be not less than 40 per cent. The amount of solution retained shall be calculated from readings of working tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

5. Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as

free from air as practicable. Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced, without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material, or until less than 5 per cent. of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more lb. per square inch. The temperature of the preservative during the pressure period shall be not less than 130°F., nor more than 190°F., and shall average at least 150°F. After the cylinder is emptied of preserving solution, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

6. At least once each day the railroad's representative shall determine penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory.

7. From ties samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting treated plugs.

8. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analysis and tests required in this specification.

Zinc-Tannin Treatment.

1. The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent.

2. The solution shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

3. The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

4. After the required amount of zinc-chloride has been injected, this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent.

solution of tannic acid, made by mixing 6⅔ lb. of 30 per cent. extract of tannin with 100 lb. of water, run in, and a pressure of 100 lb. produced and maintained one-half hour. This shall then be run off, a 1 per cent. solution of glue (made by dissolving 2-1/10 lb. of glue containing 50 per cent. gelatine in 100 lb. water) shall be admitted to the cylinder, and a pressure of 100 lb. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their organized strength in these elements.

5. The zinc chloride used shall be acid free and shall not contain more than 0.1 per cent. iron. Dry zinc chloride shall contain at least 94 per cent. soluble zinc chloride, and in any solution specified the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tram tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made. The holes made in taking these borings shall be plugged tightly and completely with creosoted plugs.

Creosote Oil (Full Cell Process)

1. Except when ordered otherwise by the railroad's representative, the material shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The preservative used shall be the one most suitable and available of the following standards of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain the amount of creosote oil necessary to permeate all of the sapwood and as much of the heartwood as practicable. The quantities specified may vary from 10 pounds per cubic foot for material from needle-leaved trees from which most of the sapwood has been removed to 24 pounds per cubic foot for piling which has wide sapwood. The quantity of creosote oil retained shall be calculated, on the

basis of 100°F., from readings of working tank gages and scales, or from weights of at least one-tenth of the material on a suitable track before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free of air as practicable. The creosote oil shall then be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 lb. per square inch until the required quantity of preservative is injected into the material, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170°F., nor more than 200°F., and shall average at least 180°F. After pressure is completed and the cylinder emptied of preservative, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

5. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

6. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

7. When permission is given to prepare material for treatment by steaming instead of seasoning by air, it shall not be subjected to pressures or temperatures for periods sufficient to injure the wood.

Zinc Chloride and Creosote Oil

(See U. S. Patents 815,404 and 1,178,132.)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent. iron. Dry zinc chloride shall contain at least 94 per cent. soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the quantity of zinc chloride required.

3. The creosote oil shall meet the standard for Grade 3 Creosote oil.

4. The material shall retain an average of 0.5 lb. of dry zinc chloride and 3 pounds of creosote oil per cubic foot, which shall permeate all of

the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent. nor more than 110 per cent. of these quantities per cubic foot.

5. The preserving mixture shall be composed of the volumetric proportions of creosote oil and of zinc chloride solution of the necessary strength which are required to obtain the specified retention of the preservatives with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative and while the preservative is being injected into the material. The strength of the zinc chloride solution shall not exceed 5 per cent. and shall be determined by analysis. Chemical titration—using a silver-nitrate solution with potassium-chromate indicator, before the zinc chloride solution is mixed with the creosote oil will usually be satisfactory. For example: With red oak the proportions shall be not less than 77 per cent. of 5 per cent. zinc-chloride solution and not more than 23 per cent. of creosote oil, and the volume injected shall be not less than 20 per cent., while with pine having a large percentage of sapwood they shall be not less than 88 per cent. of 2.5 per cent. zinc-chloride and not more than 12 per cent. of creosote oil, and the volume injected shall not be less than 40 per cent. The quantities of preservatives retained shall be calculated from readings of working tank gages or scales and from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

6. Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced the cylinder shall be drained of condensate, and if the vacuum is broken a second one as high as the first shall be created. The preserving mixtures shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 pounds per square inch until the required amount of preservative is injected into the material, or until less than 5 per cent. of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 170°F., nor more than 200°F., and shall average at least 180°F. After the cylinder is emptied of preserving mixture, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

7. At least once each day the railroad's representative shall determine

penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

8. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

9. When water gas tar solution instead of creosote is used, it shall meet the following requirements:

10. The oil shall be a water gas tar product, of which at least sixty per cent. shall be a distillate of water gas tar and the remainder shall be refined or filtered water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent. water.
2. It shall not contain more than 2 per cent. of matter insoluble in benzol.
3. The specific gravity of the oil at 38/15.5 degrees Centigrade shall not be less than 1.03 nor more than 1.07.
4. The distillate, based on water free oil, shall be within the following limits:

   Up to 210 degrees Centigrade, not more than 8 per cent.
   Up to 235 degrees Centigrade, not more than 20 per cent.
   Up to 355 degrees Centigrade, not less than 60 per cent.
5. The specific gravity of the fractions between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than .98 nor more than 1.02 at 38/15.5°C.
6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent., shall have a float test of not more than 50 seconds at 70°C.
7. The oil shall not yield more than 10 per cent. coke residue.
8. The foregoing test shall be made in accordance with the standard methods of the American Railway Engineering Association.

When a distillate of water gas tar is used, it shall meet the following requirements:

The oil shall be a distillate of water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent. of water.
2. It shall not contain more than 0.5 per cent. of matter insoluble in benzol.
3. The specific gravity of the oil at 38/15.5 degrees Centigrade shall be not less than 1.02.

4. The distillate, based on water free oil, shall be within the following limits:
   Up to 210 degrees Centigrade, not more than 5 per cent.
   Up to 235 degrees Centigrade, not more than 25 per cent.
   Up to 355 degrees Centigrade, not less than 80 per cent.
5. The specific gravity of the fractions between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than .98 nor more than 1.02 at 38/15.5°C.
6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent., shall have a float test of not more than 50 seconds at 70°C.
7. The oil shall not yield more than 2 per cent. coke residue.
8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

Creosote Oil (Empty-Cell Process with Final Vacuum)

(See U. S. Patents 707,799 and 831,450.)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be confined in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The preservative used shall be the one most suitable of the following standards of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain an average of at least 6 pounds of creosote oil per cubic foot for cross-ties and 10 pounds per cubic foot for other material, and no charge shall retain less than 90 per cent. nor more than 110 per cent. of the quantity per cubic foot that may be specified. The quantity of preservative retained shall be calculated, on the basis of 100°F., from readings of working-tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder, the preservative shall be introduced, at not over 200°F., until the cylinder is filled.

5. The pressure shall be raised and maintained until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum. The pressure and temperature within the cylinder shall be so controlled as to give the maximum penetration by the quantity of preservative injected. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches promptly created and maintained until the quantity of preservative injected is reduced to the required retention.

6. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

7. The treating plant shall be equipped with the thermometers and gages necessary to accurately indicate and record conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Creosote Oil (Empty-Cell Process with Initial Air and Final Vacuum)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of air and preservative with all surfaces.

2. The preservative used shall be the one most suitable and available of the following standards of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain an average of at least 5 lb. of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent. nor more than 110 per cent. of the quantity per cubic foot that may be specified. The amount of preservative retained shall be calculated, on the basis of 100°F., from readings of working-tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder it shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the injection of preservative necessary to insure the required retention. For example: With red oak pressures of 40 to 60 lb. for 30 minutes, while with pine having a large percentage of sapwood pressures of 70 to 90 lb. for 30 minutes will be required. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure shall be gradually raised to at least 150 lb. per square inch, and maintained until all of the sapwood

and as much of the heartwood as practicable are saturated, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170°F., nor more than 200°F., and shall average at least 180°F. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches be promptly created, and maintained until the material can be removed from the cylinder free of dripping preservative.

5. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

6. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

[10] METHODS OF ACCURATELY DETERMINING THE ABSORPTION OF CREOSOTE OIL AND CREOSOTE-COAL-TAR SOLUTION.

(1) At railroad plants the absorption should be based on the treatment which will give the most complete penetration for each class or kind of timber, specifying complete penetration of the sapwood and as much of the heart as possible for the particular species or charge; payment to be based on the amount of oil used, plus operating and other charges.

(2) Where railroads have their work done by contract, gallons should be specified for ties, posts, cross-arms and other material of uniform size, and pounds per cubic foot for other material; the same requirements as to sap and heart penetration to be applied as in the above.

[11] WATER IN CREOSOTE.

Allowable Limits of Water.

(1) The use of creosote in treatment containing up to 3 per cent. water is permissible. Where the quantity exceeds 3 per cent. proper allowance should be made, but under no circumstances shall timbers be treated with oils having more than 6 per cent. water.

Measurement of Oil.

(2) In all cases where water separates from the oil in the tank

---

[10] Adopted, Vol. 15, 1914, pp. 632, 1088; Vol. 18, 1917, pp. 1271, 1579; Vol. 20, 1919, pp. 126, 840.

[11] Adopted, Vol. 15, 1914, pp. 632, 1088.

or car, the water should be taken off to as great an extent as practicable and the oil measurement then should be made from the point of separation between the remaining water and oil as nearly as this can be determined. This refers to the physical process of measurement.

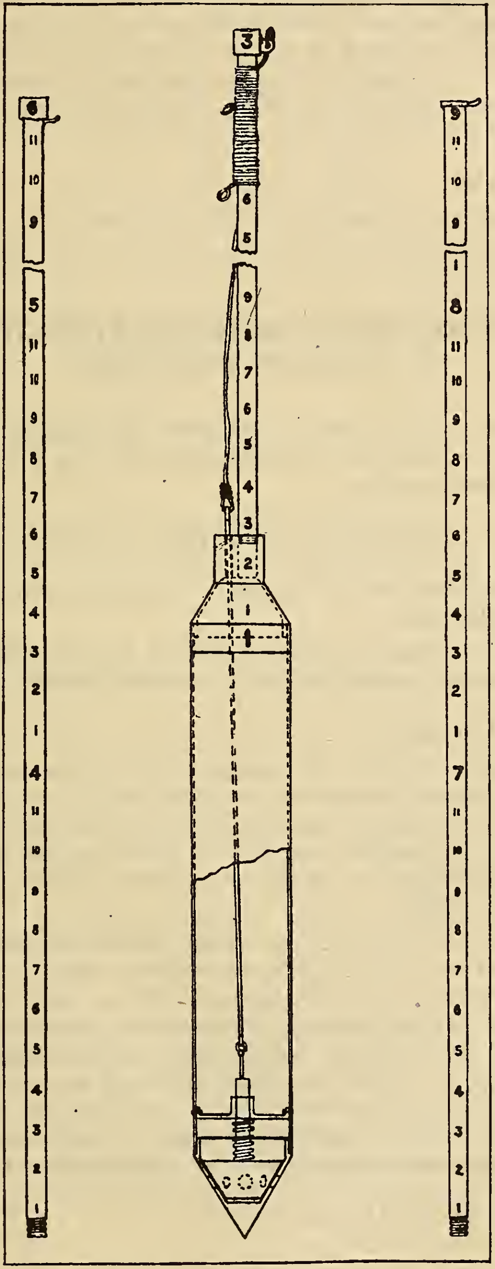


FIG. 15. DETAILS OF ZONE SAMPLING APPARATUS.

Sampling of Oil for Water Content.

(3) It is recommended as good practice that, in order to obtain accurate determinations as to the percentage of water contained in creosote oil in tank cars and in storage tanks, the principle of zone sampling be employed, as described in the 1916 report of the Committee (Proceedings, Vol. 17, pp. 447 to 456), and that for the purpose of obtaining zone samples an apparatus of the type illustrated in this report be used. (See Fig. 15.)

Storage Tanks.

(4) All storage tanks should have a watertight roof.

[12] METHOD FOR DETERMINING THE STRENGTH OF ZINC CHLORIDE SOLUTION.

Principle.—The chlorine is determined by titration with standard silver nitrate solution and then calculated into zinc chloride according to the following equation:

$$2\,AgNO_3 + ZnCl_2 = 2AgCl + Zn\,(NO_3)_2.$$

Standard Silver Nitrate Solution: 1/10 normal silver nitrate per litre of distilled water.

Indicator: Neutral potassium chromate, $K_2Cr\ O_4$ (Chlorine free), saturated solution, 60 grams in 100 cc. of distilled water.

Method of Procedure.

(a) Specific Gravity.—A quantity of zinc chloride to be tested, sufficient to float the hydrometer, is filtered into a hydrometer cylinder. Filtration is unnecessary if the solution is perfectly clear and free from Creosote Oil. The specific gravity of the filtered solution at 70° Fahrenheit is then determined by means of a hydrometer having a scale reading from 1.000 to 1.060.

(b) Titration.—Two (2) cc. of the filtered zinc chloride solution are introduced into a 500 cc. Erlenmeyer flask by means of an accurately calibrated pipette and diluted to about 100 cc. with distilled water. After adding two (2) drops of the potassium chromate indicator, the solution is titrated with the standard silver nitrate solution, using a 50 cc. glass-stoppered burette accurately graduated to tenths of a cubic centimeter. The silver nitrate solution is slowly run into the flask until the solution in the flask just begins to assume a permanent reddish tinge, the flask having been gently shaken after each addition of silver nitrate.

---

[12] Adopted, Vol. 20, 1919, pp. 133, 841.

(c) Calculation.—The per cent. strength of the zinc chloride solution is calculated according to the following equation:

$$\frac{\text{cc. AgNO}_3 \times \text{gm. Ag NO}_3 \text{ per cc.}}{\text{cc. ZnCl}_2 \times \text{Sp. Gr. ZnCl}_2} \times 100 \times .401 = \%\ \text{Strength Cl}_2$$

In this equation, the symbols signify the following:

$AgNo_3$ = Silver Nitrate; $ZnCl_2$ = Zinc Chloride;

$$0.401 = \frac{136.31}{2 \times 169.96} = \frac{ZnCl_2}{2\ AgNO_3}$$

Grams $AgNo_3$ per cc. = Strength of the standard silver nitrate solution.

Example: Strength of $AgNO_3$.................. .017 gr. per cc.
cc. of $AgNO_3$ used..................8.2
cc. of $ZnCl_2$.........................2.0
Sp. Gr. $ZnCl_2$......................1.024

$$\frac{8.2 \times .017}{2 \times 1.024} \times .401 \times 100 = 2.72\% = ZnCl_2$$

The strength of the standard silver nitrate solution should be approximately 1/10 normal or 16.996 grams $AgNO_3$ per litre. The *exact* strength of the solution must be known and should be indicated on the bottle.*

(d) Precautions.—As the above method is based on the estimation of the chlorine in the zinc chloride, it is essential to determine whether the water used in making up the zinc chloride solutions at the treating plant contains chlorides, and if so to make the proper deductions. Two (2) cc. of the water should be titrated exactly as described above. The number of cc. of standard silver nitrate solution required to produce the color change should be noted, and this amount should always be deducted from the number of cc. of silver nitrate solution required for the titration of the zinc chloride solution sample before making calculations. Where the chlorine content of the water used is found to be variable check determinations should be made.

Use.

This method is for the control of the strength of the zinc chloride solutions as used in actual treatment, and not for the analyses of the concentrated zinc chloride as purchased.

---

*The standard silver nitrate solution should be made and standardized only by a trained chemist; if the services of such a chemist are not available, the standard solution should be obtained from a reliable chemical supply firm.

[13] DIRECTIONS FOR THE USE OF IODINE POTASSIUM FERRICYANIDE STARCH COLOR REACTION TEST FOR DETERMINING ZINC CHLORINE PENETRATION.

This method requires the following chemicals and apparatus:

1. Potassium Ferricyanide.
2. Potassium Iodide.
3. Soluble Starch.
4. Atomizer.

The chemicals should be purchased chemically pure and half pound each should be enough for any plant at one time. De Vilbiss Atomizer No. 30 is very satisfactory.

For stock solutions of the three chemicals make 200 cc. each to be kept separately until used:

1. 1 per cent. Potassium Ferricyanide (2 gm. dissolved in 200 cc. water).
2. 1 per cent. Potassium Iodide (2 gm. dissolved in 200 cc. water).
3. 5 per cent. Soluble Starch (10 gm. dissolved in 200 cc. water).

Mix the weighed starch with a little of the measured cold water and then pour into the remaining water boiling hot and continue to boil until the starch is in solution. Starch solution will not keep for many days and must not be used when it begins to sour.

To make a test for zinc chloride preparation, simply pour 10 cc. each (or equal amounts) of the three stock solutions into atomizer and spray the cross-section of the tie evenly all over, if zinc chloride is present a deep blue stain will result showing clearly the depth of penetration.

[14] DETERMINATION OF ZINC IN TREATED TIMBERS.

NOTE.—*It is suggested that this method be applied by a Chemist.*

Taking Samples.

(1) The tools necessary for taking samples are a cross-cut saw and a one-inch auger. These should be wiped perfectly clean each time before taking a sample, in order to avoid contaminating the samples.

(2) The timbers from which samples are to be taken for analysis should be selected before the charge is loaded, and carefully weighed individually. They should be of average size and comparatively free from knots. After treatment they should be weighed and then piled until the dripping has stopped, when the samples may be taken.

---

[13] Adopted, Vol. 21, 1920, pp. 358, 1387.

[14] Adopted, Vol. 9, 1908, pp. 712-714, 768; Vol. 11, Part 2, 1911, pp. 746, 747, 860.

(3) For ordinary determinations, timbers such as ties should be sawed at two points, viz., two feet from the end and at the center of the tie. These sections should be designated Section No. 1 and Section No. 2, respectively. In special cases where it may be necessary to cut a tie into several sections, the exact distance from the end to each section should be given.

(4) When a large number of ties are to be analyzed, it will be sufficient to cut but one section two feet from the end, thereby saving the six-foot piece for a narrow-gage tie.

(5) After the sections have been cut, three samples should be taken from each section, as follows: No. 1, one-half inch from outside; No. 3, at the center of the section; No. 2, half-way between No. 1 and No. 3. The samples are taken by boring a hole 2 inches deep with a one-inch bit, saving all the borings. Each sample should be properly labeled, as Tie No. —, Section No. —, Sample No. —, and a list made showing the location, date, number of run, kind of treatment and weight of each tie before and after treatment.

Method of Determining Zinc-Chloride in Samples.

(6) Three grammes of dry borings should be weighed into a 250 cc. flask and three cc. concentrated sulphuric acid added. The flask should be gently heated on a sand bath or hot plate until the wood becomes thoroughly charged. A few drops of concentrated nitric acid should then be added. When the brown fumes have disappeared, a few more drops should be added, and the addition continued, a few drops at a time (toward the last the amount should be increased), until the organic matter is all destroyed. When this point is reached, the liquid will remain colorless on further heating. The flask should then be allowed to cool and diluted with 100 cc. of water (the water should be added carefully at first). As a rule, the residue in the flask will be completely dissolved, but if there should be a slight sediment, it may be disregarded. Ammonium hydroxide should be added until distinctly alkaline, and allowed to cool. If there is a precipitate of iron hydroxide, or if there has been any undissolved sediment in the flask, it should be filtered; if not, it should be poured into a 400 cc. beaker and 5 cc. ammonium sulphide added and allowed to stand over night. It should then be filtered into an 11 cm. filter paper, washing thoroughly with water containing ammonium sulphide, and dried. It should then be incinerated in a porcelain crucible and roasted until the zinc-chloride is converted to zinc oxide. The weight should be divided by three and the result multiplied

by 1.674, which will give the number of grammes of zinc-chloride contained in one gramme of the wood examined, or the number of pounds per pound. To convert this result into pounds of zinc-chloride per cubic foot of wood, multiply by the weight in pounds of one cubic foot of the wood.

[15] FORMS FOR REPORTING INSPECTION.

Two forms for reporting inspection of treatment are shown. Form "A" provides a record of the treatment and the determination of the absorption of the preservative by gage readings. Form "B" provides a record of the determination of the absorption by weighing.

These forms are intended as general guides for reporting and keeping records of the inspection of the treatment of timbers, and may be varied to suit any special kind of treatment.

The following is explanatory of the gage readings, designated by letter on Form "A":

Reading "A"—Is the reading of the measuring tank gage before the oil is put into the cylinder.

Reading "B"—Is the tank gage reading when the cylinder is completely filled.

Reading "C"—Is the tank gage reading when the pumping of the oil into the cylinder is stopped.

Reading "D"—Is the tank gage reading after all the oil from the charge is returned to the measuring tank.

Reading "A" minus "D," corrected for temperatures, gives the number of gallons used in the charge.

Reading "B" minus "C" gives the number of gallons pumped into the timber after the cylinder is filled and is used to give the gross absorption for high processes where oil is taken out of the timber by an initial air pressure, or by a final vacuum, or both. There will be a discrepancy in this gross absorption, due to the amount of oil absorbed by the timber while cylinder is being filled.

---

[15] Adopted, Vol. 14, 1913, pp. 713-716, 1165, 1166.

Form A.

M. W. 1700

____
(Name of Railroad)

______________________________ Department

______________________________ Plant

______________________________ Inspector

Date															
Kind of Treatment															
Retort Number															
Charge Number															
Liquid Used															
Percent of Chloride															
Steam or Air Admitted															
Vacuum Applied															
Liquid Admitted															
Pump Started															
Treatment Ended															
Steam or Air Pressure, Lbs.															
Vacuum, Inches															
Pressure of Liquid, Lbs.															
Measuring Tank Number															
Gallons per Tank Foot															
Reading A.															
Temperature A. Degrees Fahrenheit															
Reading B.															
Temperature B. Degrees Fahrenheit															
Reading C.															
Temperature C. Degrees Fahrenheit															
Reading D.															
Temperature D. Degrees Fahrenheit															
Gals. Pumped Into Timber per Charge B. minus C.															
Gallons Pumped Into Timber per Tie															
Pounds Pumped Into Timber per Cu. Ft.															
Total Gallons Used 100° Fahrenheit A. minus D.															
Gals per Cu. Ft. of Timber															
Gallons per Tie															
Lbs. per Cu. Ft. of Timber															
Lbs. of Chloride per Cu. Ft. Timber															
Material Treated.															

Form B.

M. W. 1701

Date __________ ____________________ (Name of Railroad) Date __________

Kind of Treatment __________ __________ Plant Kind of Treatment __________

Run No. ________ Kind of Timber __________ Kind of Timber __________ Run No. ________

Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie	Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie

____________________ Inspector

Lbs. of Oil Per Tie __________ % of Chloride in Solution __________

Total Gals. Oil @ 100° Fahr. __________ Total Lbs. Liquid Used __________

Gals. Absorbed per Tie __________ Lbs. Chloride per Tie __________

____________________ Inspector

Lbs. of Oil Per Tie __________ % of Chloride in Solution __________

Total Gals. Oil @ 100° Fahr. __________ Total Lbs. Liquid Used __________

Gals. Absorbed per Tie __________ Lbs. Chloride per Tie __________

COMMITTEE XVIII.

ELECTRICITY.

[1]DEFINITIONS.

Bond.—A metallic means for connecting conductors to permit passage of electric current.

Bonder.—An employe assigned to install or maintain bonds and their appurtenances.

Bracket Support.—An arm supporting the trolley wire or catenary.

Bridge Support.—A rigid overhead structure supporting the trolley wire or catenary.

Cable Conductor.—Wires bound together acting as a conductor.

Catenary Suspension.—Any form of trolley construction supported by a longitudinal wire or cable.

Clearance Line (Equipment).—The line beyond which no part of the equipment shall project.

Clearance Line (Third Rail).—The line beyond which no part of the third rail structure shall project.

Conductor.—A metallic path for the flow of electricity.

Contact Conductor.—That part of the distribution system other than the traffic rails which is in immediate electrical contact with the circuits of the cars or locomotives.

Contact Rail.—A rigid contact conductor.

Contact Rail (Overhead).—A rigid contact conductor above the elevation of the maximum equipment line.

Cross-Span Support.—Overhead wire or cable supporting the trolley wire or catenary.

Direct Suspension.—Any form of overhead trolley construction in which the trolley wires are attached by insulating devices directly to the main supporting system.

Distributing System.—That portion of the conductor system which carries current of the kind and voltage received by the cars or locomotives.

Duct Line.—A structure consisting of one or more tubes and chambers for the housing of wires or cables.

Duct or Conduit.—A unit length of pipe suitable for use in the construction of runways for electric wires or cables.

Jumper.—A cable used to connect the ends of two contact conductors.

Linemen.—Employees assigned to install or maintain wire and cables and their appurtenances.

Mandrel.—A tool used for aligning and cleaning ducts.

---

[1] Adopted, Vol. 12, Part 1, 1911, pp. 152, 222; Vol. 13, 1912, pp. 510, 998; Vol. 20, 1919, pp. 194, 854; Vol. 22, 1921, pp. 140, 969.

MANHOLE.—An opening in a splicing chamber through which a man may enter.

PATROLMEN.—Employees assigned to inspect track and third rail structures, cables and wires.

PULLING CHAMBER.—A chamber in a duct line provided for pulling cables and wires into ducts.

SPLICING CHAMBER.—A chamber in a duct line, in which cables are spliced and inspected.

SUBSTATION.—A structure and its contained group of apparatus or machinery which receives current from a transmission system, changes its kind or voltage and delivers it to a distribution system.

THIRD RAIL.—A contact conductor placed at either side of the track, the contact surface of which is located a few inches above the level of the top of the track rails.

THIRD RAIL GAGE.—Distance measured parallel to plane of top of both running rails between gage of nearest running rail and inside gage line of third rail.

TRACTION LINEMEN.—Employees assigned to install or maintain wires and cables and their appurtenances for all railroad voltages.

TRANSMISSION SYSTEM.—That portion of the conductor system carrying current of a kind or voltage different from that received by the cars or locomotives.

TRANSMISSION LINE.—A system of towers or poles and cables or wires carrying current from the source of power to the substations.

TROLLEY WIRE.—A flexible contact conductor customarily supported above the cars.

[3]OVERHEAD CLEARANCE LINES FOR PERMANENT WAY STRUCTURES ON ELECTRIFIED RAILWAYS.

Momentary obstruction, such as signal blades, may approach pantagraph clearance line.

Sway of pantagraph based on 1 inch difference in height of car springs; ½ inch difference in elevation of track rail, and sway of 6 inches either side at 22 feet above top of rail for pantagraph itself.

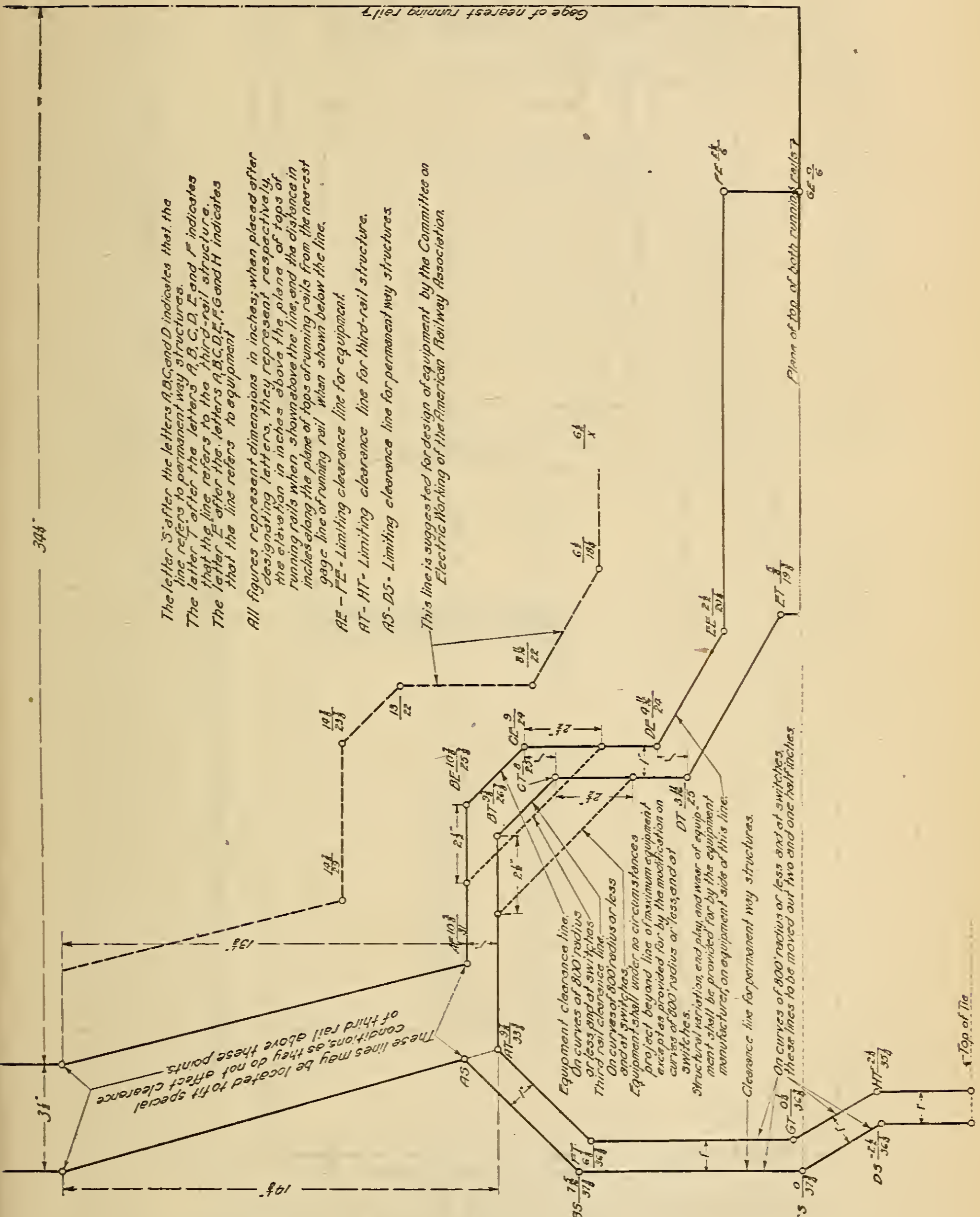
These diagrams show minimum clearance; additional clearances will be required to provide for special features of design, sag between points of support as affected by length of span and temperature changes, and also for steady strains, pull-offs, etc., if any.

All heights to be measured at right angles to plane of rails at center line of track.

---

[3] Adopted, Vol. 15, 1914, pp. 618-624, 1071.

²CLEARANCE LINES FOR EQUIPMENT AND PERMANENT WAY STRUCTURES ADJACENT TO THIRD RAIL AND FOR THIRD RAIL STRUCTURE.



The letter "S" after the letters A, B, C, and D indicates that the line refers to permanent way structures.
The letter "T" after the letters A, B, C, D, E and F indicates that the line refers to the third-rail structure.
The letter "E" after the letters A, B, C, D, E, F, G and H indicates that the line refers to equipment.

All figures represent dimensions in inches; when placed after designating letters, they represent respectively, the elevation in inches above the plane of tops of running rails when shown above the line, and the distance in inches along the plane of tops of running rails from the nearest gage line of running rail when shown below the line.

AE – FE – Limiting clearance line for equipment.

AT – HT – Limiting clearance line for third-rail structure.

AS – DS – Limiting clearance line for permanent way structures.

This line is suggested for design of equipment by the Committee on Electric Working of the American Railway Association.

These lines may be located to fit special conditions, as they do not affect clearance of third rail above these points.

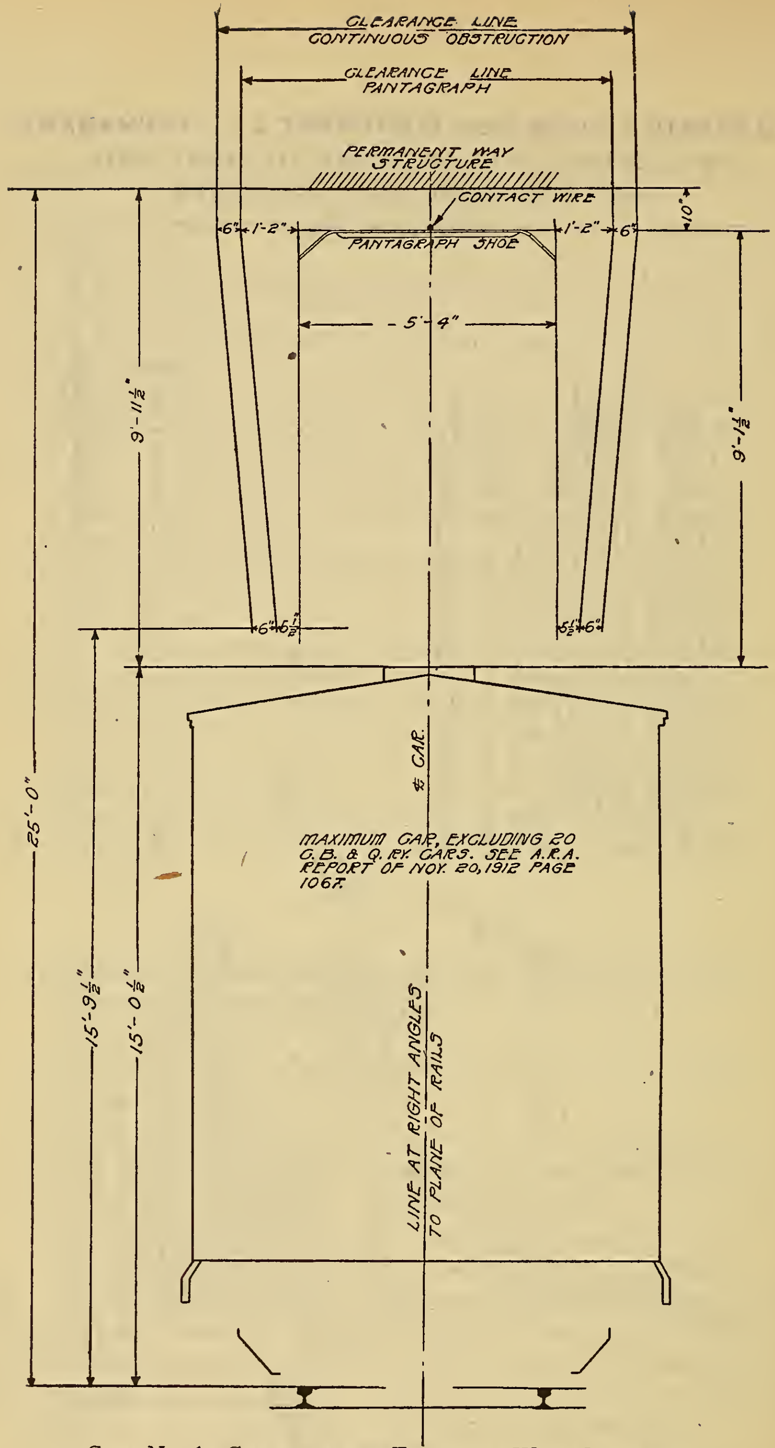
Equipment clearance line.
On curves of 800' radius or less and at switches.
Third rail clearance line.
On curves of 800' radius or less and at switches.
Equipment shall under no circumstances project beyond line of maximum equipment except as provided for by the modification on curves of 800' radius or less, and at switches.
Structural variation, end play, and wear of equipment shall be provided for by the equipment manufacturer, on equipment side of this line.

Clearance line for permanent way structures.

On curves of 800' radius or less and at switches, these lines to be moved out two and one half inches.

---

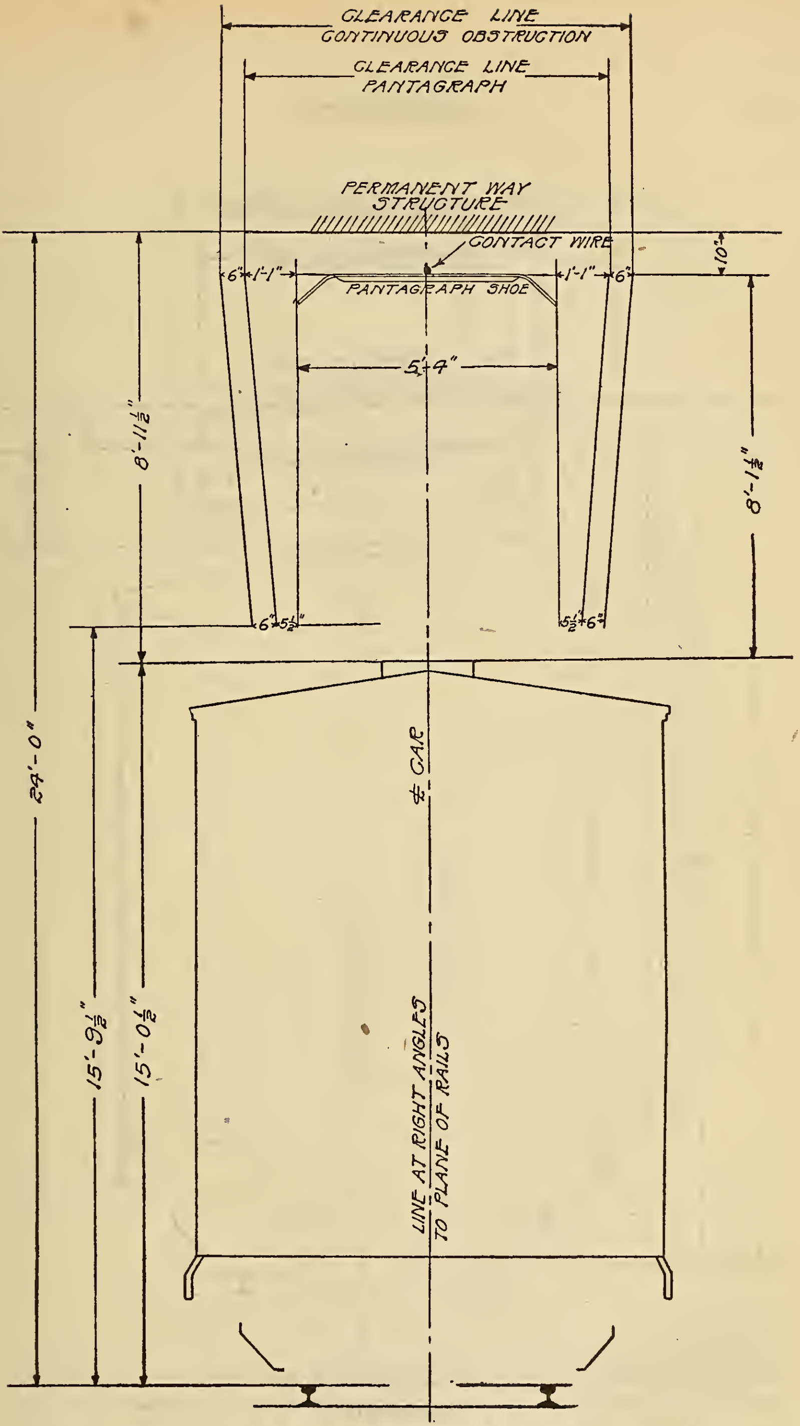
[2] Adopted, Vol. 13, 1912, pp. 511, 525, 998; Vol. 16, 1915, pp. 927, 1187.


CLEARANCE LINE CONTINUOUS OBSTRUCTION
CLEARANCE LINE PANTAGRAPH
PERMANENT WAY STRUCTURE
CONTACT WIRE
10"
6" 1'-2"
1'-2" 6"
PANTAGRAPH SHOE
5'-4"
9'-11½"
9'-1½"
6" 6½"
6½" 6"
25'-0"
15'-9½"
15'-0½"
℄ CAR
MAXIMUM CAR, EXCLUDING 20 C.B. & Q. RY. CARS. SEE A.R.A. REPORT OF NOV. 20, 1912 PAGE 1067.
LINE AT RIGHT ANGLES TO PLANE OF RAILS

Case No. 1—Clearance for Trainman With Lantern.

ASSUMPTIONS.

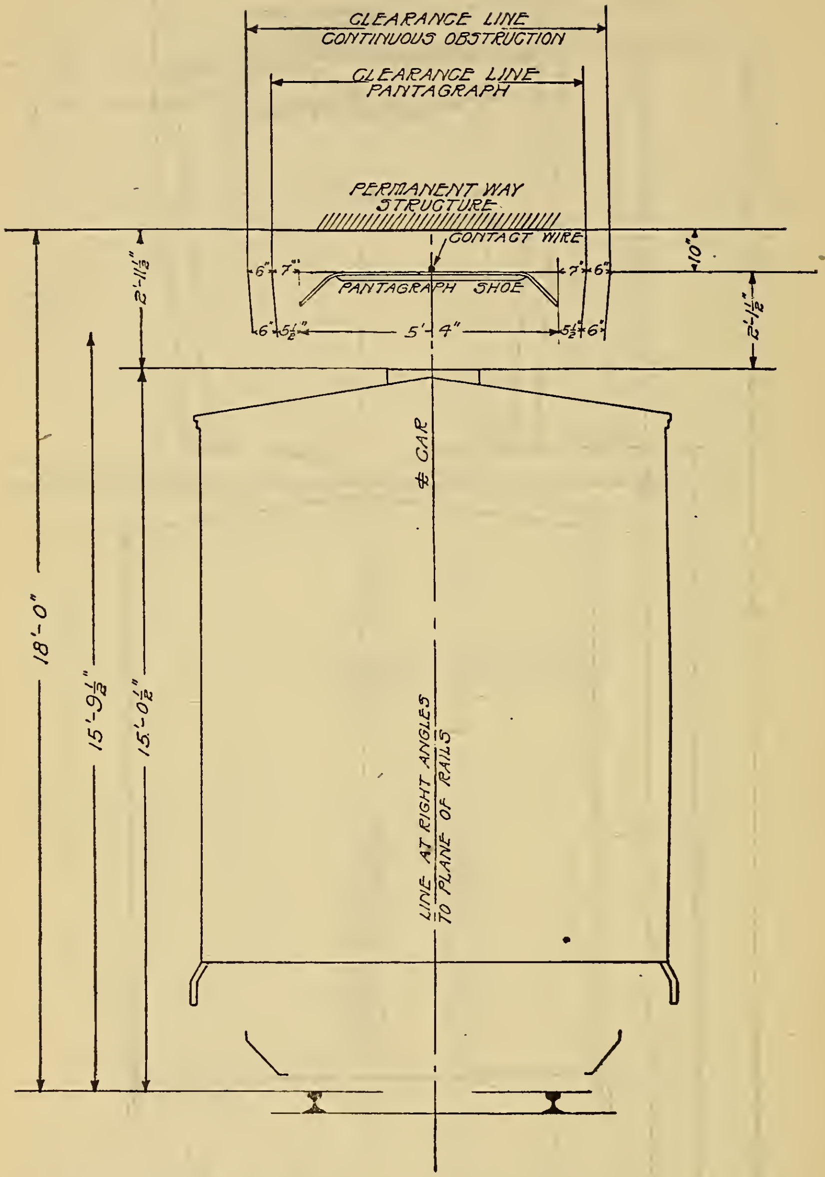
Reach of 6-foot trainman	7 feet 8 inches
Lantern swing	1 foot 0 inches
Clearance	0 feet 5½ inches
Total distance car running board to wire	9 feet 1½ inches



Case No. 2—Clearance for Trainman Without Lantern.

ASSUMPTIONS.

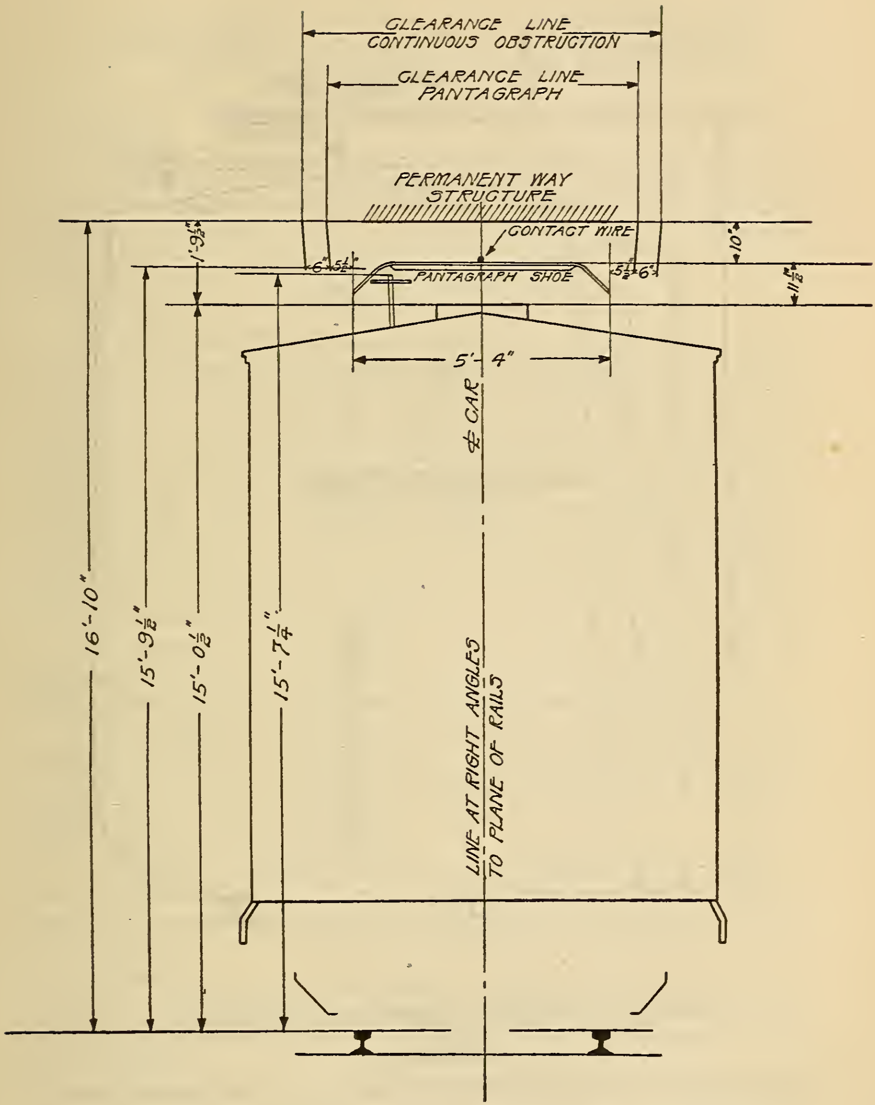
Reach of 6-foot trainman	7 feet 8 inches
Clearance	0 feet 5½ inches
Total distance car running board to wire	8 feet 1½ inches



Case No. 3—Normal Minimum Clearance Without Trainman on Cars.

ASSUMPTION.

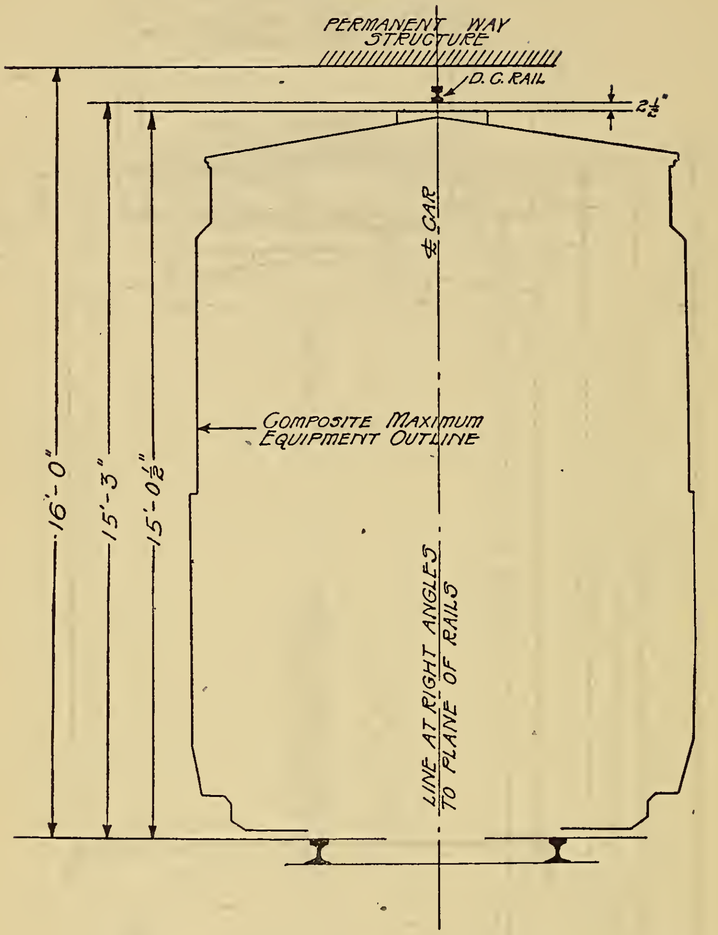
Normal distance car running board to wire............2 feet 1½ inches



Case No. 4—Special Minimum Clearance Without Trainman on Cars.

ASSUMPTION.

Minimum distance car running board to wire..........0 feet 11½ inches


PERMANENT WAY STRUCTURE
D. C. RAIL
2½"
℄ CAR
COMPOSITE MAXIMUM EQUIPMENT OUTLINE
16'-0"
15'-3"
15'-0½"
LINE AT RIGHT ANGLES TO PLANE OF RAILS

Case No. 5—Minimum Clearance D. C. Overhead.

ASSUMPTION.

Minimum distance car running board to rail...........0 feet 2½ inches

[*] RAILWAY SPECIFICATIONS FOR ELECTRIC LIGHT, POWER SUPPLY AND TROLLEY LINES CROSSING STEAM AND ELECTRIC RAILWAYS.

(Approved by American Railway Association, November 19, 1919.)

1. Intention.

The purpose of these specifications is to describe the general requirements for crossings of electric light, power supply and trolley lines over and under the tracks and wires and across the property of steam and electric railways.

2. General.

(a) *Drawings*—The Crossing Company shall prepare drawings of the proposed crossing and, with its application, submit for approval of the Railroad four prints showing the plan, profile and details of the line at the crossing. The data required is listed on the diagrams attached and shall be furnished by the Crossing Company making application for a crossing permit. Should modification of these plans be agreed upon, the Crossing Company shall make the necessary changes on the tracings and supply four additional prints. Unless otherwise agreed no work shall be started until the drawings have been approved by the Railroad. No additions or alterations shall subsequently be made to the crossing span or its supports without the approval of the Railroad.

(b) *Permits and Notices*—The Crossing Company shall obtain all necessary permits and shall notify the Railroad of its intention to begin work at least one week in advance of beginning work in the field.

(c) *Inspection*—The work shall be subject to the inspection of the Railroad, and its interpretation of the drawings and specifications, and its decision as to the quantity and quality of the labor and materials, shall be final. Defective material will be rejected and shall be removed and replaced with acceptable material.

The Crossing Company shall secure for the Inspector of the Railroad free access to the mills, shops and works where the material is being manufactured, and shall provide free of expense all necessary facilities for making tests.

(d) *Patents*—The Crossing Company shall bear the cost of any suit which may arise, and shall pay all damages which may be awarded against the Railroad in consequence of the use under these specifications of any patented device.

(e) *Signs*—For purposes of identification poles or structures supporting the crossing span shall be clearly marked with the name, initials or trademark and the pole numbers of the Crossing Company.

When required by the Railroad, the Crossing Company shall place on all crossing structures, located on the property of the Railroad, warning signs of an approved design.

(f) *Fire Hazard*—Crossing poles and towers shall be located as far distant as practicable from inflammable structures. The space around the poles and towers shall be kept free from underbrush, grass and other inflammable material.

---

[*] Adopted, Vol. 21, 1920, pp. 208, 1378.

(g) *Clearing.*—False-work, plant, materials and rubbish incidental to the construction shall be removed as the work will permit, and at its completion the site shall be left clean and unobstructed.

(h) *Galvanizing or Sherardizing*—When required, galvanizing or sherardizing shall be done in accordance with the specifications given in Appendix IV.

(i) *Maintenance*—The crossing shall be maintained to the satisfaction of the Railroad by the Crossing Company and in such condition that the stresses mentioned in Section 6 shall not be exceeded.

(j) *Terminology*—The terminology used in these specifications is the same as that employed in the National Electrical Safety Code. (See Section 1 of the Code for definitions of special terms.)

(I) Overhead Crossing of Electric Light and Power Supply Lines.

3. Scope.

Overhead crossings of electric light and power supply lines, irrespective of voltage, shall conform to Sections 1 to 18 inclusive of these specifications. Where telegraph, telephone and other signal lines cross on the same supports with supply lines at crossings they shall conform to these specifications. (See Sections 4 (b), 15 (b) and (c).)

4. Clearances.

(a) *Clearance above Rails*—The clear headroom shall be not less than 30 feet above the top of rail under the most unfavorable conditions for wires and cables of 50,000 volts or less. For higher potentials the clearance shall be increased ½ inch for each 1,000 volts excess.

The elevation above the rail of the lowest wire at the insulator supports when strung with the minimum allowable sag (see Appendix I) shall be at least equal to the sum of the clear headroom above specified, the sag of the wire at 120 degrees Fahrenheit and the sag due to pole deflection, if any. (See Diagram D.)

(b) *Clearance between Lines*—Under the most unfavorable conditions, the clearance of circuits crossing above wires or cables of another pole line shall be not less than eight feet for circuits of over 5,000 volts alternating current or 750 volts direct current and not less than four feet for other circuits. (See Section 5 (e), 15 (c).)

The side clearance between crossing poles or towers and any part of existing pole lines paralleling the tracks of the Railroad shall be not less than six feet.

(c) *Clearance between Poles and Tracks*—The side clearance of poles and towers from the nearest track rail shall be not less than twelve feet unless physical conditions or municipal requirements prevent; except that at sidings the clearance may be not less than seven feet. At loading sidings, sufficient space shall be left for a driveway. (See Sections 2 (f) and 8.)

(d) *Clearance from Buildings and Bridges*—The overhead clearance between supply conductors and railroad buildings or bridges shall be not less than ten feet and the side clearance not less than six feet.

(e) *Separation of Conductors*—For spans not exceeding 150 ft. the separation of parallel conductors on the same pole line shall be not less than that given in the following table:

Table I.

Line Voltages	*Separation*
Exceeding 0 volts but not exceeding 7,000 volts	12 in.
Exceeding 7,000 volts but not exceeding 14,000 volts	20 in.
Exceeding 14,000 volts but not exceeding 27,000 volts	30 in.
Exceeding 27,000 volts but not exceeding 35,000 volts	36 in.
Exceeding 35,000 volts but not exceeding 47,000 volts	45 in.
Exceeding 47,000 volts but not exceeding 70,000 volts	60 in.
70,000 volts separation 60 in. plus 0.6 in. for each k.v. in excess of 70.	

For spans exceeding 150 ft. the spacing shall be increased depending upon the length of the span and the sag of the conductors, but this requirement for increased spacing need not apply to wires of the same phase or polarity between which there is no difference of potential.

(f) *Clearance between Conductors and Supports*—The clearance in any direction between the conductors and the pole or tower supporting them shall be not less than that given in the following table:

Table II.

Exceeding 0 but not exceeding 10,000 volts	9 in.
Exceeding 10,000 but not exceeding 14,000 volts	12 in.
Exceeding 14,000 but not exceeding 27,000 volts	15 in.
Exceeding 27,000 but not exceeding 35,000 volts	18 in.
Exceeding 35,000 but not exceeding 47,000 volts	21 in.
Exceeding 47,000 but not exceeding 70,000 volts	24 in.
70,000 clearance 24 in. plus 0.25 in. for each k.v. in excess of 70.	

5. Loading Conditions.

(a) *General*—The continental territory of the United States shall be divided into three districts, as shown on the District Loading Map, Diagram C. Crossing wires and supporting structures shall be designed for heavy, medium or light loads, depending upon the district in which they are located. In special cases, when it is known from the Weather Bureau, or other reliable reports, that the climatic conditions at a crossing vary materially from those specified for its district, the Railroad may require a stronger construction or approve a lighter one, based on such data.

(b) *Wires and Cables—Heavy Loading*—The conductors, messenger wires and aerial ground wires shall be designed to sustain a uniformly distributed load equal to the resultant of the dead load, the weight of a coating of ice ½ in. in radial thickness and a wind pressure of 8 lb. per square foot on the ice-covered diameter of the wires at a temperature of 0 degree Fahrenheit.

Medium Loading—The load shall equal the resultant of the dead load, the weight of a coating of ice ¼ in. in radial thickness and a wind pressure of 8 lb. per square foot on the ice-covered diameter of the wires at a temperature of 15 degrees Fahrenheit.

Light Loading.—The load shall equal the resultant of the dead load and a wind pressure of 8 lb. per square foot on the wires at a temperature of 32 degrees Fahrenheit; the wires being assumed to be free of ice.

The weight of the ice shall be assumed as 57 lb. per cubic foot. (0.033 lb. per cu. in.)

(c) *Insulators and Pins*—The combined strength of the insulators and pins supporting the crossing and next adjoining spans in the construction specified in Section 13 (b) (see Diagrams G and H) shall withstand three times the stress resulting from the breaking in one of the spans of the wire which they support while the other span is carrying the maximum load for which it is designed. (See Sections 12 and 13.)

(d) *Cross-Arms*—The cross-arms shall withstand the loading upon the wires specified in Section 5 (a) and (b), assuming either all wires unbroken or the two wires broken, which will cause the maximum stress in the cross-arm for the unbalanced condition, except that wires of 500,000 c.m., or larger, shall not be included among such broken wires. Wires of such large size shall, however, be fastened to each side of the cross-arm with suitable strain insulators of sufficient strength to hold the wires in case they should be burned off at the cross-arm. (See Section 11.)

(e) *Supports—Heavy Loading*—The poles or towers of the crossing span shall be designed to withstand the combined stresses of their own weight, a wind pressure of 12 lb. per square foot upon the projected area of cylindrical surfaces and 20 lb. per square foot on flat surfaces, and a load upon the wires of the crossing span and next adjoining spans on each side equal to the resultant of the dead load of the wires, the weight of a coating of ice ½ in. in radial thickness and a wind pressure of 12 lb. per square foot on the ice-covered diameter of the wire at a temperature of 0 degree Fahrenheit.

The projected area of latticed structures shall be considered to consist of the sum of the projected areas of the members in the windward and leeward surfaces, but such projected area shall not be taken in excess of the projected area of the structure as a whole. The supporting structure shall be assumed to be free of ice.

Medium Loading—The wind pressure shall be the same as for heavy loading, but the temperature shall be assumed to be 15 degrees Fahrenheit and the ice coating ¼ in. in radial thickness.

Light Loading—The wind pressure shall be the same as for heavy loading, but the temperature shall be assumed to be 32 degrees Fahrenheit and the wires free of ice.

Broken Wires—The pole or towers shall withstand the unbalanced tension of the following broken wires under the loading conditions specified for the district in which they are located:

Table III.

2 Broken wires on poles or towers carrying 5 wires or less.
3 Broken wires on poles or towers carrying 6 to 10 wires.
4 Broken wires on poles or towers carrying 11 to 16 wires.
25 per cent. of wires on poles or towers carrying 17 or more wires.

In computing the stresses due to the above broken wires, that combination shall be selected which will make the stresses in the pole or tower a maximum, except that for poles or towers carrying more than six wires no more than two broken wires shall be considered attached to any one arm. When the wires are of 500,000 c.m., or larger size, the poles and towers shall not be required to withstand the unbalanced tension of any such broken wire.

Deflections—The pole or towers may be permitted a reasonable deflection under their specified loading, provided that such deflection, in combination with the elongation of the wires, shall not reduce the clearance specified in Section 4 (a), the clearance specified in Section 4 (b) more than 25 per cent., or produce stresses in excess of those specified in Section 6.

(f) *Guys*—Where poles, not self-supporting, are guyed, the guys shall be considered as taking the horizontal component of the entire load; the poles, as struts, resisting the vertical component. (See Section 17.)

6. Working Stresses.

In design of the crossing and its supports and next adjacent spans the following unit stresses shall not be exceeded:

Table IV.

(a) *Structural Steel:*	*Lb. per sq. in.*
Tension (net section)	18,000
Shear (net section)	14,000
Compression	$15{,}000-75\frac{l}{r}$

l = length of the member in inches.

r = least radius of gyration of the section in inches.

(b) *Rivets and Pins:*	*Lb. per sq. in.*
Shear	14,000
Bearing	28,000
Bending	28,000

(c) *Bolts, Field Rivets or Countersunk Rivets:*	
Shear	11,000
Bearing	22,000

Table V.

(d) *Wires and Cables:*	*Lb. per sq. in.*
Copper, hard-drawn, solid, A.w.g. 0000, 000, 00	25,000
Copper, hard-drawn, solid, A.w.g. 0	27,500
Copper, hard-drawn, solid, A.w.g. No. 1	28,500
Copper, hard-drawn, solid, A.w.g. Nos. 2, 4, 6	30,000
Copper, soft-drawn, solid	17,000
Copper, hard-drawn, stranded	30,000
Copper, soft-drawn, stranded	17,000

Aluminum, hard-drawn, stranded, A.w.g., under 0000	12,000
Aluminum, hard-drawn, stranded, A.w.g., 0000 and over	11,500
Steel wire (Siemens-Bartin steel)	38,000
(e) *Concrete:*	
Compression	700
Shear	50
Steel reinforcing bars	18,000

TABLE VI.

(f) *Untreated Wood* (See Sections 10 and 11):

	Permissible Bending Lb. per sq. in.	*Fiber Stresses Compression Lb. per sq. in.*
Bald Cypress (Heartwood)	800	800 $(1 - \frac{L}{60D})$
Catalpa	500	500 "
Cedar, Eastern White	600	600 "
Cedar, Idaho	850	850 "
Cedar, Port Orford	1,150	1,150 "
Cedar, Red	700	700 "
Cedar, Washington	850	850 "
Cedar, Western White	850	850 "
Chestnut	850	850 "
Douglas Fir	900	900 "
Juniper	550	550 "
Longleaf Yellow Pine	1,000	1,000 "
Redwood	650	650 "
Shortleaf Yellow Pine	800	800 "
White Oak	950	950 "

L = length in inches.
D = least side, or diameter, in inches.

(g) *Treated Wood*—When wood is creosoted at or above 212 degrees Fahrenheit only 80 per cent. of the values in Section 6 (f) shall be used. (See Section 10 (b).)

(h) *Deterioration and Maintenance*—When wood deteriorates to the point where the unit stresses are increased to 50 per cent. in excess of those specified in Section 6 (f) and (g) it shall be removed and replaced by new timber.

7. Foundations.

(a) The foundations for steel poles and towers shall be designed to prevent their overturning. Only the earth included in the inverted frustrum lying above the base of the foundation and having sides inclined at 30 degrees from the vertical shall be considered effective. (See Diagrams E and F.)

In good ground the weight of the earth shall be assumed as not more than 100 lb. per cu. ft. The weight of the concrete shall be assumed as 140 lb. per cu. ft.

In swampy ground special measures shall be taken to prevent uplift or depression of foundations. When foundations are submerged allowance shall be made for buoyancy.

(b) The design of concrete structures, the materials used, and the processes employed in making concrete shall conform to the recommendations of the Joint Committee on Concrete and Reinforced Concrete. (See Proceedings, A. S. T. M. of 1917, Part I, page 202, Vol. 17.)

The proportions of the concrete for pole and tower foundations and in anchorages shall be one part Portland cement, three parts sand and six parts ¾ in. broken stone or gravel.

The placing of the concrete on each part of the work shall proceed continuously until completed.

(c) The top of the concrete foundations of poles or towers shall be not less than one foot above the surface of the ground or high water, and shall be sloped to shed water. (See Diagrams E and F.)

(d) Where located in swampy ground, wood crossing poles and the next adjoining wood poles shall be set in barrels of broken stone or gravel, or in broken stone contained in timber cribbing.

(e) Where located in the sides of banks, or where subjected to washouts, the foundations shall have an additional depth and shall be protected by cribbing or riprap where necessary.

(f) Back filling for foundations or pole settings shall be tamped in six-inch layers or puddled.

8. Location of Supports.

The crossing poles or towers shall preferably be located outside the Railroad's right-of-way. The supports for the crossing and next adjoining spans shall be located in a straight line where practicable. (See Diagrams A and B.) (See Sections 2 (f) and 4 (c).)

9. Steel Poles and Towers.

(a) Steel crossing poles and towers shall be self-supporting unless otherwise especially approved by the Railroad.

(b) The structural and rivet steel shall be open-hearth steel fulfilling the requirements of the Standard Specifications for Structural Steel for Buildings, Serial Designation A9-16, and revisions thereto, of the American Society for Testing Materials.

(c) The frame shall be of such form that the stresses may be computed with reasonable accuracy, or the strength shall be determined by actual test. The design and workmanship shall be strictly first-class. The construction shall be such that all the parts exposed to the weather or open to the circulation of air are accessible for inspection, cleaning and painting. Where pockets that would otherwise hold water or dirt are unavoidable they shall be filled with concrete.

(d) The minimum thickness of metal shall be ¼ in. The minimum size of angles shall be 2 by 2 in. and of bolts or rivets ⅝ in. Net sections shall be used in proportioning for tension. In deducting rivet holes, they shall be taken ⅛ in. greater in diameter than the rivets.

(e) Compression members shall be constructed according to the best modern practice so as to develop the full strength of the section. The unsupported length of any main compression member shall not exceed 150 times its least radius of gyration. The length of any secondary member, that is, one that does not carry computed stresses, shall not exceed 200 times its least radius of gyration.

(f) So far as practicable, connections shall be capable of developing the full strength of the members connected, and shall be so designed as to avoid stresses due to eccentricity. Any unavoidable eccentricity in members or connections shall be provided for. Joints, whether in tension or compression members, shall be fully spliced.

(g) The distance from the center of any rivet hole to the edge of the piece shall not be less than one and one-half times the diameter of the rivet nor exceed eight times the thickness of the material, and the distance between centers of rivet holes shall be not less than three diameters of the rivet.

(h) Unless special approval of the Railroad is obtained, all connections shall be riveted.

Where rivets transfer stress, the pitch shall be not over six inches nor more than sixteen times the minimum thickness of the material connected. Wherever practicable, rivets shall be machine driven, and when driven shall completely fill the holes, the heads being in full contact with the surfaces, neatly finished and concentric with the rivet hole. Loose or defective rivets shall be carefully cut out and replaced. They shall be drilled out if necessary to avoid injuring the material. The diameter of the finished rivet hole shall be not more than one-sixteenth of an inch larger than the diameter of the cold rivet.

(i) If their use is approved, bolts shall be carefully turned and accurately fitted. Snug fitting washers shall be used under the nuts. Threads shall not bear on the metal of the members connected. Bolt threads shall be jammed onto the nuts.

(j) All members shall be carefully straightened at the shop before assembling, and when riveted shall be free from twists and bends. All portions of the work exposed to view shall be neatly finished.

(k) Structural steel shall be thoroughly cleaned at the shop and be galvanized or sherardized, or be given one coat of approved paint. Holes shall be made in material before galvanizing or sherardizing. Contact surfaces shall be given one coat of an approved paint before assembling, unless galvanized or sherardized. Painted steel shall be given two coats of an approved paint after erection and after all other work is completed. The surface of the steel shall be thoroughly cleaned of all dirt, grease, scale, etc., before painting, and no painting shall be done in freezing or rainy weather, or on damp surfaces.

10. Wood Poles.

(a) Wood poles shall be reasonably straight, well proportioned from top to butt and peeled. They shall have the butt cut square and the top roofed. They shall be free from defects which would seriously decrease their strength or durability. Poles shall be selected from the species of wood mentioned in Section 6 (f) or other species approved by the Railroad, and shall otherwise conform to the Specifications for Wood Poles in Appendix III. (See Section 6 (h).)

(b) Wood poles shall be treated with a preservative preferably by either the closed or open tank process. With the latter, the treatment need not extend higher than two feet above the ground, except in the case of yellow pine, which shall have full-length treatment. (See Section 6 (g).)

When directed, the poles shall be encased in concrete six inches thick, extending from three feet below to one foot above the ground level and the upper surface shall be sloped away from the pole.

(c) Wood poles shall be set to the following depths:

Length of Pole	*Depth in Solid Rock*	*Depth in Firm Earth*
25 ft.	3 ft. 0 in.	5 ft. 0 in.
30 ft.	3 ft. 6 in.	5 ft. 6 in.
35 ft.	4 ft. 0 in.	6 ft. 0 in.
40 ft.	4 ft. 0 in.	6 ft. 0 in.
45 ft.	4 ft. 6 in.	6 ft. 6 in.
50 ft.	4 ft. 6 in.	7 ft. 0 in.
55 ft.	5 ft. 0 in.	7 ft. 6 in.
60 ft.	5 ft. 0 in.	8 ft. 0 in.
65 ft.	6 ft. 0 in.	8 ft. 6 in.
70 ft.	6 ft. 0 in.	9 ft. 0 in.
75 ft.	6 ft. 0 in.	9 ft. 6 in.
80 ft.	7 ft. 0 in.	10 ft. 0 in.
85 ft.	7 ft. 0 in.	10 ft. 6 in.
90 ft.	7 ft. 0 in.	11 ft. 0 in.

(d) Wood poles supporting the crossing span shall be head-guyed away from the crossing span and the next adjoining pole shall be guyed toward the crossing span.

The crossing pole shall be side-guyed in both directions where practicable. Otherwise the line shall be side-guyed as near as possible to the crossings, but not more than 500 ft. from the nearest crossing structure. (See Diagrams B, H and I.)

11. Cross-Arms.

Cross-arms on crossing and next adjoining poles may be of wood or steel. When of wood, they shall be double and of pieces not less than 3¼ by 4¼ in. in section. Double arms shall be held together with properly fitted spacers and bolts placed immediately adjoining the outside pins. They shall be held to the pole by through bolts and be properly braced. (See Sections 5 (d), 6 (f), Diagrams G and H.)

12. Pins.

Insulator pins shall be of steel, wrought-iron, malleable iron or other approved metal or alloy and shall be galvanized or otherwise protected from corrosion. (See Section 5 (c).)

13. Insulators (For Trolley Insulators See 13 (d)).

(a) *Material and Construction*—Insulators shall be of porcelain for all voltages. Insulators, both pin type and suspension type, shall meet the mechanical and electrical requirements of these specifications. (See

Sections 5 (c) and 13 (c).) Pin type insulators for circuits not exceeding 7,000 volts shall be of one-piece construction and there shall be a bearing contact between the pin and the insulator above the plane of the center of the tie wire groove.

Nothing in these specifications shall prevent the use of insulators designed for greater voltages than that at which the particular line is operated.

(b) *Insulators at Crossings*—Insulators at crossings shall preferably be of the disc or suspension type. (See Diagrams E and F.) When pin type are used, two shall be provided for each conductor at the crossing and at the next adjacent poles or towers to take the stress. (See Sections 5 (c) and 11, also Diagrams G and H.)

(c) *Tests*—Insulators shall be so designed that, with excessive potential, failure will first occur by flash-over and not by puncture. Pin insulators and strings of insulators of the suspension type shall withstand the potentials specified in Table VIII at a frequency of 60 cycles for three minutes without puncturing or flashing over.

Flash-over voltages shall be determined by the following formula:

$$\text{Wet (Voltage in kv.)} = 10 + 2y + 0.0012y^2 - 0.000{,}017y^3$$
$$\text{Dry (Voltage in kv.)} = 20 + 3y - 0.000{,}85y^2 - 0{,}000{,}022y^3$$
$$y = \text{Circuit voltage in kv.}$$

TABLE VIII.

Nominal Voltage of the Circuit	*Flash-over Voltages*	
	Dry	*Wet*
0-750	22,000	11,500
2,300	27,000	14,500
4,000	32,000	18,000
Nominal Voltage of the Circuit	*Flash-over Voltages*	
	Dry	*Wet*
6,600	40,000	23,000
7,500	42,500	25,000
11,000	53,000	32,000
22,000	85,500	54,000
33,000	117,000	77,000
44,000	148,000	99,000
55,000	181,000	123,000
66,000	208,000	142,000
88,000	262,000	184,000
110,000	310,000	222,000
150,000	377,000	280,000
200,000	410,000	322,000

By the term "wet" is meant a condition equivalent to a precipitation of one-fifth inch of rain per minute at an angle of 45 degrees to the axis of the insulator. In other respects the tests shall conform to the latest Specifications for Insulator Testing of the A. I. E. E.

Test voltages above 35,000 volts shall be determined by the A. I. E. E. standard spark gap method.

Test voltages below 35,000 volts shall be determined by transformer ratio.

(d) *Strain Insulators in Guys and in Trolley Wire Spans*—Strain insulators shall have a mechanical strength at least equal to the guys or trolley span wires in which they are placed. They shall be designed to withstand the same dry flash-over tests as the line insulators of the circuit of the highest potential at the crossing.

14. Tie Wires and Clamps.

Tie wires, clamps or other conductor fastenings at poles or towers shall be such as to hold the wires under maximum loading with shattered insulators or wires broken or burned at the insulator without allowing an amount of slip which would materially reduce the clearance specified in Section 4 (a) and (b). The conductors shall be so protected at the point of attachment to the insulator that an arc at such a point will not cause the crossing conductor to fall. (See Diagram G.)

15. Spans.

(a) *General*—Preferably the crossing and next adjacent spans shall be dead-ended at the crossing poles or towers using insulators of the disc or suspension type and connected by jumpers supported on pin insulators, as shown on Diagrams E and F.

Where pin insulators are used the spans shall be so designed that there is no upward stress on the crossing insulators and the construction shall be as shown on Diagrams G and H.

Unusually long crossing spans shall be avoided wherever practicable, and adjacent spans shall differ preferably not more than 50 per cent. from the length of the crossing span. The sags shall be not less than those specified in Appendix I. The normal mechanical tension in the conductors shall be the same in the crossing span and the adjacent spans on each side.

The conductors shall not be spliced in the crossing span nor in either adjacent spans. Taps to the conductors in the crossing span are objectionable and shall not be made except in connection with the construction shown on Diagrams E and F.

Cradles or overhead bridges will not be permitted beneath the spans crossing the tracks of the Railroad, except in special cases and by permission of the Railroad.

(b) *Conductors*—The conductors shall be hard-drawn copper, aluminum or other non-corrodible material unless other material is approved.

The minimum size of hard-drawn copper conductors in spans of less than 150 ft. and for potentials less than 5,000 volts shall be of No. 6 A. w. g., and for spans of 150 ft. and over or for higher potentials, No. 4 A. w. g. The minimum size for aluminum cables shall be No. 1 A. w. g. for all spans and voltages.

Conductors shall be stranded when of aluminum or when larger than No. 0000 A. w. g.

(c) *Signal Line Crossing.*—Electric light and power supply lines shall normally cross over telegraph, telephone and other signal wires. Where this is not practicable the conductors occupying the upper position shall be considered as included in the class of power circuits of the highest voltage below them. (See Sections 4 (b), 5 and 6.)

(d) *Aerial Ground Wires*—Aerial ground wires in the crossing span and the adjacent spans shall be of galvanized standard steel not less than 5/16 in. in diameter and having a breaking strength of not less than 4,500 lb.; or they may be of the same material as the conductors, with the same working stresses. (See Section 5 (b), 6 (d) and 18 (c).)

16. Guy Anchorages.

Guys to ground shall be connected to a well-anchored rod. The anchorage shall preferably consist of steel encased in concrete and shall be capable of resisting twice the maximum tension in the guy.

The eye of the anchor rod shall be located at least one foot above the ground. Rods less than one inch in diameter shall be galvanized or sherardized. When required, the anchor rod shall be enclosed in a galvanized iron pipe, which shall be filled with Portland cement mortar, extending from the anchorage to one foot above ground. (See Diagram H.)

Details of the anchor shall be definitely shown on the drawings.

17. Guys.

(a) Guys shall be galvanized or copper-covered strand-steel cable not less than 5/16 in. in diameter, or galvanized rods, having an ultimate tensile strength of not less than 4,500 lb. Wooden braces may be used in place of guys. (See Section 5 (f) and 10 (d).)

(b) Guys shall be attached to crossing structures below the cross-arms when the voltage of the circuit is in excess of 750 volts. (See Diagrams G and H.)

(c) When strain insulators are installed in guys (see Section 18 (d)), they shall be located so as to give, if possible, a clearance of at least six feet to the pole guyed. If there is only one insulator in the guy it shall be located at such a point that should the guy break at or above the insulator the upper end will not swing within eight feet of the ground. (See Diagram G.)

In head guys a second insulator shall be located at least eight feet from the ground and where practicable not less than six feet from the pole. (See Diagram B.)

(d) The ground end of guy wires or cables attached to ground anchors exposed to traffic shall be provided with a substantial and conspicuous wooden or metallic guard extending not less than eight feet above ground. In exposed or poorly lighted locations such guards shall be painted white or some other conspicuous color.

18. Grounding.

(a) *Poles and Towers*—Steel crossing poles and towers carrying circuits of over 750 volts shall be grounded through an artificial ground electrically connected to a main upright member at the foundation. Structures having multiple footings shall have at least two legs connected to separate artificial grounds. (See Diagrams E and F.)

Where wood crossing poles or towers are used, the methods of protection shall be either of the following: the pins and cross-arms shall not be grounded and guys shall be insulated; or the pins, cross-arms and guys shall be grounded to permanently moist earth. (See Diagrams G and H.)

The methods of protection shall be designated by the Railroad except in the case of a crossing on a public highway or other public lands where the method of protection is especially prescribed by the Public Service Commission or other regulatory body having jurisdiction. (See Section 18 (d).)

(b) *Artificial Grounds*—Artificial grounds may consist of ground plates, galvanized iron pipes or other special types, when approved by the Railroad. Ground plates shall be of copper of at least No. 14 (.064 in.) A. w. g., not less than two feet square. They shall be buried in permanently moist earth with not less than six inches of charcoal on each side of the plate, or its equivalent. One edge of the ground plate shall be rolled into a terminal for at least six inches and the ground wire soldered therein or connected by other approved construction.

Alternate—In permanently moist earth the artificial ground may consist of two or more galvanized iron pipes not less than one inch in diameter, driven at least seven feet into the ground. The ground wire shall be wrapped about the pipe and securely soldered thereto.

Note: When permanently moist earth is not available the details of the artificial ground shall be subject to special approval by the Railroad.

(c) *Aerial Ground Wires*—On steel structures the aerial ground wire shall be clamped or bonded thereto. On wood structures it shall be supported on insulators and shall not be grounded at the crossing or the next adjacent support on either side. (See Section 15 (d) and Diagrams E, F and G.)

(d) *Guys*—Guys on steel crossing structures carrying circuits exceeding 750 volts shall be electrically connected to the structure at the upper end of the guy.

Where the structure is of wood or where the voltage of the circuit on steel structures does not exceed 750 volts, strain insulators shall be placed in the guy, except when the guy is effectually grounded to permanently moist earth. (See Sections 13 (d), 17 (b)-(c), 18 (a), also Diagrams G and H.)

(e) *Ground Wire*—The ground wire shall be of copper of sufficient capacity to insure the opening of the line in case of short-circuit, but in no case less than No. 4 A. w. g. in size.

The ground wire shall be attached to steel structures by an expanded copper terminal or other approved fastening and connected to the artificial ground with as few bends as possible and no sharp bends. (See Diagrams E and F.)

(II) Trolley Line Crossings.

19. General.

(a) The overhead wires of electric railways crossing the tracks of the Railroad at grade shall conform to the requirements of Part II of these specifications.

(b) The trolley contact wire shall be placed at the same elevation above the trolley rails throughout the crossing and for not less than 100 feet on either side.

Where this is not practicable, live trolley guards of approved construction shall be installed, except where the crossing is protected by gates. (See Section 23 (a).)

Crossing spans shall be as short as possible. Catenary construction shall be used for spans exceeding 100 feet.

(c) Typical arrangements of trolley contact wire crossings are shown on Diagrams I and J.

(d) The features of trolley line construction are covered in Part I or in both Part I and Part II.

20. Clearances.

The clear headroom of the trolley contact wires shall be not less than 22 feet above the top of rail under the most unfavorable conditions, and that of trolley feeders paralleling such contact wires, 25 feet, when of not over 750 volt potential, and 30 feet for higher potentials. (See Section 4 (a).)

21. Trolley Wire Construction.

(a) *Materials and Sizes*—The trolley contact wire shall be of hard-drawn copper or other material not subject to rapid wear and, when installed, shall be not less than No. 00 A. w. g. in size.

(b) *Anchors*—At the third pole on each side of the crossing, or as near as possible thereto, the trolley contact wires shall be anchored. Strain poles shall be self-supporting or be securely guyed.

(c) *Splicing*—Neither the trolley contact wire nor its supporting wires shall be spliced between the points of anchorage.

22. Trolley Guards.

(a) *Live Trolley Guards*—Live trolley guards shall be of such length that when the car is approaching the crossing the trolley wheel shall be within the guard when the forward bumper is 50 feet from the nearest rail of the crossing, and shall remain within the guard until the rear bumper of the car has cleared the last rail of the crossing by eight feet. (See Section 19 (b).)

(b) *Insulating Trolley Guards*—Wood insulating trolley guards shall be used on underbridge crossings when any part of the bridge structure comes within six inches of the trolley pole when in its highest position. They shall extend beyond the structure at least eighteen inches. (See Diagram K.) (See Section 26 (d).)

23. Span Construction.

(a) *Poles*—Tubular poles shall be at least of standard weight pipe; the minimum size of which shall be for two-section poles, six and seven-inch pipe, and for three-section poles five, six and seven-inch pipe. The poles shall be fitted with caps and shall have protective sleeves at the ground level.

When of approved design, other types of poles may be used.

(b) *Guys*—The poles adjacent to the crossing shall be guyed away from the crossing and, when feasible, away from the trolley contact wire. (See Diagrams I and J.)

(c) *Span Wires*—Span wires shall be galvanized high-strength stranded steel cables not less than $\frac{5}{16}$ in. in diameter, copper-covered stranded steel or bronze cables of equivalent strength. At the span on each side of the crossing the span wires shall be double.

(d) *Span Insulators*—Each span shall contain strain insulators located approximately over the outer rails of the trolley tracks. (See Section 13 (d).)

(e) *Bracket Construction*—Brackets shall be of the flexible span type with over-supporting rod arm of commercial steel tubing or pipe of 1.9 in. external diameter and walls not less than 0.145 in. thick. The flexible span shall be of galvanized high-strength stranded steel cable not less than $\frac{5}{16}$ in. in diameter, or copper-covered stranded steel or bronze cables of equivalent strength.

(f) *Catenary Construction*—Where catenary construction is required (see Section 19 (b)), full details of the design and calculations shall be furnished with the application for the crossing permit. (See Diagram J.)

24. High Potential Trolleys.

Electric railways operating at over 750 volts shall comply with the provisions of Part II of these specifications, with the following additional provision:

Preferably the trolley contact conductor shall be anchored and insulated at each side of the crossing so that the crossing span shall be normally dead. It shall be made alive for the passage of cars and at other times be grounded.

(III) Underbridge Crossings.

(Except Trolley Wires.)

25. Underbridge Crossings.

(a) Circuits of bare and weatherproof wires of not over 750 volts may be carried in open construction under bridges and attached thereto, provided the portion of the circuit under the bridge and for six feet each side is rubber-covered and is supported in accordance with Diagram K and Sections 11, 12, 13 (a) and (c), and 18 (b) and (e).

(b) Lead-covered insulated supply wires and cables crossing under bridges and attached thereto shall be placed in conduit and supported from the bridge at proper intervals. The conduit shall be of metal, unless fiber or other insulating conduit is approved by the Railroad.

The conduit shall extend six feet beyond the structure. Metal conduit shall be insulated from the structure and grounded. There shall be a clearance between the conduit and the abutment of at least three feet.

Armored insulated cables shall be suspended by metal clips from a messenger wire, which shall be grounded at the pole nearest the bridge.

(c) The minimum clearance, unless otherwise approved, between the wires supported from a bridge and the bridge steel work shall be one foot; from the nearest abutment three feet, and between wires nine inches.

The distance between supports attached to the bridge shall not exceed twenty feet.

Bare conductors crossing beneath a bridge and not attached thereto shall have a clearance of at least eight feet from the structure.

(d) Attachments to steel bridges shall be made by devices that do not require the drilling or cutting of the bridge superstructure, and the metal parts shall be so insulated as to prevent stray current from entering upon the structure. (See Section 23 (b).)

(IV) Underground Crossings.

26. Underground Crossings.

The portion of the underground crossings beneath the tracks and for at least six feet beyond the rails shall be of conduit.

The top of the conduit shall be approximately four feet below the base of rail and not less than two feet six inches below the surface of the ground at the lowest point of crossing of the property of the Railroad.

The ducts shall be encased in concrete three inches in thickness.

The conduit shall be laid with a uniform slope of not less than three inches in 100 feet, to drain away from the Railroad property.

(I) TABLES AND CURVES OF CONDUCTOR SAGS.

In the following tables and curves are given the minimum allowable sags at which conductors should be strung in order that when loaded with the specified requirement of ½ in. of ice and a wind load of 8.0 lb. per sq. ft. on the projected area at 0 degree Fahrenheit the tension in the conductor will not exceed the working stress specified in Section 6. The sags given in the tables for 120 degrees Fahrenheit are greater in every case than the vertical component at 0 degree Fahrenheit under the maximum wind and ice load. The moduli of elasticity and coefficients of expansion used are given in Appendix II, Table 9, Properties of Wire Material.

Table 1.

MINIMUM SAGS FOR STRANDED HARD-DRAWN BARE COPPER WIRES.

No. 0000 A. w. g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet
—20	2	3	5	8	13	20	3.5	6	10
0	2	4	5	9	14	22	3.5	6.5	10.5
20	3	4	6	10	16	24	4	7	11.5
40	3	4	6	11	18	27	4.5	8	12
60	3	5	7	13	20	31	5	8.5	13
80	4	6	8	15	24	35	5.5	9	13.5
100	4	7	10	17	27	40	6	10	14.5
120	5	8	12	20	31	46	7	10.5	15

No. 000 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet
—20	2	3	5	8	13	21	4	7	12
0	2	4	5	9	15	23	4	7.5	12.5
20	3	4	6	10	17	25	4.5	8.5	13.5
40	3	4	6	12	19	29	5	9	14
60	3	5	7	13	22	33	6	9.5	15
80	4	6	8	15	25	38	6.5	10.5	15.5
100	4	7	10	18	29	43	7	11	16
120	5	8	12	23	34	49	7.5	12	17

Table 1—Continued.

No. 00 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet
—20	2	3	5	9	14	23	4.5	9	15
0	2	4	5	10	16	26	5	9.5	15.5
20	3	4	6	11	18	29	5.5	10	16
40	3	4	7	12	21	33	6	11	17
60	3	5	7	14	24	37	6.5	11.5	17.5
80	4	6	9	16	28	43	7	12	18
100	5	7	10	19	32	48	8	12.5	18.5
120	6	9	12	23	37	54	8.5	13.5	19.5

No. 0 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet
—20	2	3	5	9	16	2.5	5.5	11.5	18.5
0	2	4	5	10	18	2.5	6.5	12	19
20	3	4	6	11	21	3	7	12.5	19.5
40	3	5	7	13	24	3.5	7.5	13	20
60	3	5	8	15	27	4	8	14	20.5
80	4	6	9	18	32	4.5	8.5	14.5	21.5
100	5	7	11	21	37	5	9	15	22
120	6	9	13	25	42	5	9.5	15.5	22.5

Table 2.

MINIMUM SAGS FOR SOLID HARD-DRAWN BARE COPPER WIRES.

No. 1 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet
—20	2	4	5	10	19	3	8	14.5	23
0	3	4	6	11	22	3.5	8.5	15	23.5
20	3	4	6	13	25	4	9	16	24
40	3	5	7	15	30	4.5	9.5	16	24.5
60	4	6	8	18	34	5	10	17	25
80	4	7	10	21	39	5.5	10.5	17	25.5
100	5	8	12	25	44	6	11	18	26
120	6	10	16	30	49	6	11.5	18	26.5

TABLE 2—Continued.

No. 2 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet
—20	2	4	5	12	25	4	10.5	18.5	29
0	3	4	6	14	29	4.5	11	19	29.5
20	3	5	7	16	33	5	11.5	19.5	30
40	3	5	8	19	39	5.5	12	20	30.5
60	4	6	10	23	43	6	12.5	20.5	31
80	4	7	12	27	48	6.5	13	21	31
100	5	9	14	31	53	7	13	21.5	31.5
120	7	11	18	35	58	7.5	13.5	22	32

No. 3 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	3	4	6	17	3	6	14	24	37.5
0	3	4	7	20	3.5	6.5	14.5	24.5	37.5
20	3	5	8	23	4	7	15	25	38
40	3	6	10	27	4.5	7.5	15	25	38
60	4	7	12	30	5	8	15.5	25.5	38.5
80	5	9	14	35	5.5	8.5	16	26	39
100	6	11	17	39	5.5	8.5	16.5	26	39
120	8	14	22	44	6	9	16.5	26.5	39.5

No. 4 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400	500	600
	SAGS								
	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	3	4	8	25	5	9	18	31	46
0	3	5	9	29	5.5	9	18.5	31.5	46
20	3	6	11	33	6	9.5	19	31.5	46.5
40	4	7	13	38	6.5	10	19	32	46.5
60	4	9	16	42	6.5	10	19.5	32.5	47
80	5	11	19	46	7	10.5	19.5	32.5	47.5
100	7	13	23	50	7.5	11	20	32.5	47.5
120	9	16	27	54	7.5	11	20.5	33	48

TABLE 2—Continued.

No. 6 A.w.g.—SPAN IN FEET

Temp. Fahr.	100 or Less	125	150	200	250	300	400
	SAGS						
	Inches	Inches	Inches	Inches	Feet	Feet	Feet
—20	3	8	22	5.5	10	15	30
0	4	10	26	6	10	15	30
20	5	13	30	6	10.5	15.5	30.5
40	6	16	33	6	10.5	15.5	30.5
60	8	19	36	6.5	11	16	31
80	10	22	39	6.5	11	16	31
100	13	25	41	7	11.5	16.5	31
120	16	28	44	7	11.5	16.5	31.5

TABLE 3.

MINIMUM SAGS FOR STRANDED BARE ALUMINUM WIRES.

No. 0000 A.w.g.—SPAN IN FEET

Temp. Fahr.	80 or Less	100	125	150	200	250	300	400	500	600
	SAGS									
	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	1	2	3	5	11	2.5	5	11	19	29
0	1	2	3	6	15	3	5.5	12	19.5	29.5
20	2	3	5	8	21	3.5	6	12.5	20.5	30
40	2	4	7	11	27	4.5	7	13	21	31
60	4	6	11	17	34	5	7.5	13.5	21.5	31.5
80	6	10	16	22	41	5.5	8	14	22	32
100	10	14	20	27	46	6	8.5	14.5	22.5	33
120	13	18	25	32	52	6.5	9	15	23	33.5

No. 000 A.w.g.—SPAN IN FEET

Temp. Fahr.	80 or Less	100	125	150	200	250	300	400	500	600
	SAGS									
	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	1	2	3	5	12	3	5.5	13	22	33.5
0	1	2	4	6	17	3.5	6.5	13.5	22.5	34
20	2	3	5	8	24	4.5	7	14	23	34.5
40	2	4	7	12	31	5	7.5	14.5	23.5	35
60	3	5	11	18	38	5.5	8	15	24	35.5
80	6	9	16	23	43	6	8.5	15.5	24.5	36
100	10	13	20	29	49	6.5	9	16	25	36.5
120	13	17	25	33	54	7	9.5	16.5	25.5	37

TABLE 3—Continued.

No. 00 A.w.g.—SPAN IN FEET

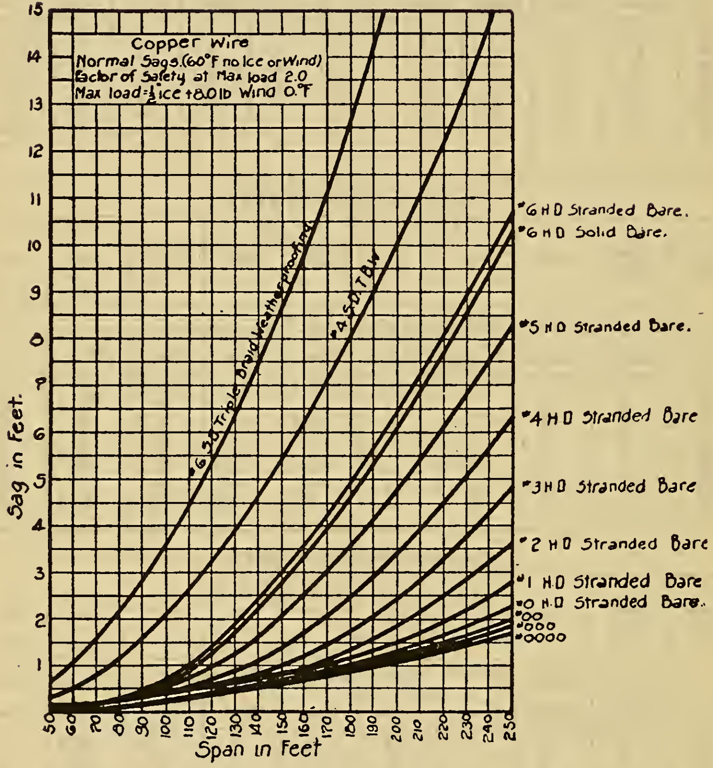
Temp. Fahr.	80 or Less	100	125	150	200	250	300	400	500	600
	SAGS									
	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet	Feet
—20	1	2	3	6	2	5	8.5	16.5	28	42
0	2	2	4	8	2.5	5.5	9	17	28.5	42.5
20	2	3	6	12	3	6	9	17.5	29	43
40	2	4	9	18	3.5	6.5	9.5	18	29.5	43
60	4	7	14	24	4	7	10	18.5	29.5	43.5
80	7	12	19	29	4.5	7	10.5	19	30	44
100	10	16	24	33	5	7.5	11	19.5	30.5	44.5
120	14	19	28	38	5.5	8	11.5	20	31	44.5

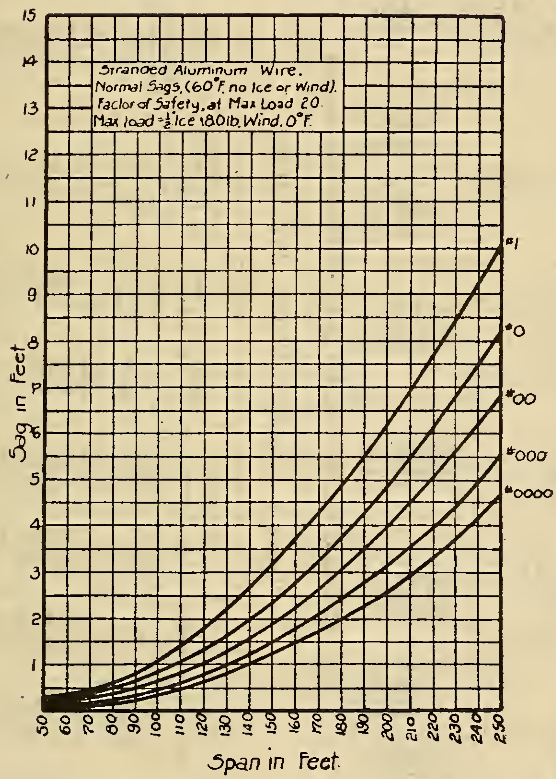
No. 0 A.w.g.—SPAN IN FEET

Temp. Fahr.	80 or Less	100	125	150	200	250	300	400	500
	SAGS								
	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	1	2	4	9	3.5	7	10.5	21	36.5
0	2	3	6	14	4	7	11	21.5	36.5
20	2	4	8	20	4.5	7.5	11.5	22	37
40	3	6	13	26	5	8	12	22	37
60	5	10	18	31	5	8.5	12	22.5	37.5
80	8	14	23	35	5.5	8.5	12.5	23	38
100	12	18	27	39	6	9	13	23	38
120	15	21	31	43	6	9.5	13.5	23.5	38.5

No. 1 A.w.g.—SPAN IN FEET

Temp. Fahr.	80 or Less	100	125	150	200	250	300	400	500
	SAGS								
	Inches	Inches	Inches	Inches	Feet	Feet	Feet	Feet	Feet
—20	1	3	7	20	5	9	13.5	26.5	43.5
0	2	4	11	25	5.5	9	14	27	43.5
20	2	5	16	30	5.5	9.5	14.5	27	44
40	4	9	21	34	6	10	14.5	27.5	44
60	7	13	25	39	6.5	10	15	27.5	44.5
80	10	18	29	42	6.5	10.5	15.5	28	44.5
100	14	21	32	45	7	11	15.5	28	45
120	17	24	36	49	7	11	16	28.5	45


Copper Wire
Normal Sags.(60°F no Ice or Wind)
Factor of Safety at Max load 2.0
Max load=½ ice +8.0 lb Wind 0°F
*6 S.D. Triple Braid Weatherproofing
*4 S.D. T.B.W
*6 H D Stranded Bare.
*6 H D Solid Bare.
*5 H D Stranded Bare.
*4 H D Stranded Bare
*3 H D Stranded Bare
*2 H D Stranded Bare
*1 H.D Stranded Bare
*0 H.D Stranded Bare.
*00
*000
*0000
Sag in Feet.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Span in Feet
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


Stranded Aluminum Wire.
Normal Sags, (60°F. no Ice or Wind).
Factor of Safety, at Max Load 2.0.
Max load = ½ Ice 8 lb. Wind. 0°F.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Sag in Feet
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Span in Feet
#1
#0
#00
#000
#0000

(II)

TABLE 4. STEEL WIRE—STRANDED—GALVANIZED.

Diam.	Number and Gauge of Wires Roebling W. G.	Area Square Inches	Guy Wire	Ultimate Strength in Lbs.			Load Per Lin. Ft. Vertical in Lbs.		Load Per Lin. Ft. Horizontal in Lbs. 8.0 Lbs. Per Sq. Ft. ½-in. Ice	Max. Load Per Lin. Ft. Plane of Resultant in Lbs.	E×A E=29,000,000 Lbs. Per Sq. In.
				Siemens-Martin 75,000 Lbs. Per Sq. In.	High Tension 125,000 Lbs. Per Sq. In.	Ex. High Tension 187,000 Lbs. Per Sq. In.	Dead	Dead+ ½-in. Ice			
⅞-in.	....	....	....	....	....	....	....	....	1.250	....	....
13/16-in.	....	....	....	....	....	....	....	....	1.208	....	....
¾-in.	....	....	....	....	....	....	....	....	1.167	....	....
11/16-in.	....	....	....	....	....	....	....	....	1.125	....	....
⅝-in.	7-5	0.2356	....	19,000	25,000	42,000	....	....	1.083	....	6,832,000
9/16-in.	7-6½	0.1922	....	14,500	21,100	34,500	0.668	1.329	1.042	....	5,573,800
½-in.	7-8	0.1443	8,500	11,000	18,000	27,000	0.510	1.132	1.000	1.510	4,184,700
7/16-in.	7-9	0.1204	6,500	9,000	15,000	22,500	0.415	0.998	0.958	1.383	3,491,600
⅜-in.	7-11+	0.0832	5,000	6,800	10,500	17,250	0.295	0.839	0.917	1.243	2,412,800
5/16-in.	7-12	0.0606	3,800	4,860	8,100	12,100	0.210	0.715	0.875	1.130	1,757,400

(Table of ultimate strength as furnished by the John A. Roebling's Sons Co.)

TABLE 5. COPPER WIRE—STRANDED.

Gauge A.w.g.	Diam. Inches	Area Sq. In.	Hard-Drawn		Soft-Drawn		Load Per Lin. Ft. Vertical in Lbs.		Load Per Lin. Ft. Horizontal in Lbs. 8.0 Lbs. Per Sq. Ft. ½-in. Ice	Max. Load Per Lin. Ft. Plane of Resultant in Lbs.	Hard-Drawn E×A in Lbs. (E=16,000,000 Lbs. Per Sq. In.)	Soft-Drawn E×A in Lbs. (E=12,000,000 Lbs. Per Sq. In.)
			Ultimate Tension Lbs.	Allowable Tension Lbs.	Ultimate Tension Lbs.	Allowable Tension Lbs.	Dead	Dead + ½-in. Ice				
500,000	0.819	0.3924	23,540	11,750	13,340	6,650	1.525	2.345	1.213	2.640	6,278,400	4,708,800
450,000	0.770	0.3535	21,210	10,600	12,020	6,000	1.373	2.163	1.180	2.464	5,636,800	4,242,000
400,000	0.728	0.3141	18,860	9,400	10,680	5,350	1.220	1.984	1.152	2.294	5,025,600	3,769,200
350,000	0.679	0.2750	16,500	8,250	9,350	4,650	1.068	1.801	1.119	2.120	4,400,000	3,300,000
300,000	0.630	0.2360	14,160	7,100	8,025	4,000	0.915	1.618	1.087	1.949	3,776,000	2,832,000
250,000	0.590	0.1965	11,790	5,900	6,680	3,350	0.762	1.440	1.060	1.788	3,144,000	2,358,000
0000	0.530	0.1662	9,970	5,000	5,650	2,800	0.645	1.286	1.020	1.641	2,659,200	1,994,400
000	0.470	0.1318	7,910	3,950	4,480	2,250	0.513	1.116	0.980	1.485	2,108,800	1,581,600
00	0.420	0.1045	6,270	3,150	3,555	1,750	0.406	0.978	0.947	1.361	1,672,000	1,254,000
0	0.375	0.0829	4,970	2,500	2,820	1,400	0.322	0.866	0.917	1.261	1,326,400	994,800
1	0.330	0.0657	3,940	1,950	2,235	1,100	0.255	0.771	0.887	1.175	1,051,200	788,400
2	0.291	0.0521	3,130	1,550	1,770	900	0.203	0.695	0.861	1.107	833,600	625,200
3	0.261	0.0413	2,480	1,250	1,405	700	0.160	0.633	0.841	1.053	660,800	495,600
4	0.231	0.0328	1,970	1,000	1,115	550	0.127	0.582	0.821	1.006	524,800	393,600
5	0.206	0.0260	1,560	800	885	450	0.101	0.540	0.804	0.970	416,000	312,000
6	0.184	0.0206	1,235	600	700	350	0.080	0.505	0.789	0.936	329,600	247,200

TABLE 6. COPPER WIRE—SOLID.

Gauge A.w.g.	Ext. Diam. Inches	Area of Conductor Sq. In.	Hard-Drawn		Soft-Drawn		Load Per Lin. Ft. Vertical in Lbs.		Load Per Lin. Ft. Horizontal in Lbs. 8.0 Lbs. Per Sq. Ft. ½-in. Ice	Max. Load Per Lin. Ft. Plane of Resultant in Lbs.	Hard-Drawn E×A in Lbs. E= 16,000,000 Lbs. Per Sq. In.	Soft-Drawn E×A in Lbs. (E= 12,000,000 Lbs. Per Sq. In.)
			Ultimate Tension Lbs.	Allowable Tension Lbs.	Ultimate Tension Lbs.	Allowable Tension Lbs.	Dead	Dead + ½-in. Ice				
0000	0.460	0.1662	8,310	4,150	5,650	2,800	0.641	1.238	0.973	1.575	2,659,200	1,994,400
000	0.410	0.1318	6,590	3,300	4,480	2,250	0.509	1.074	0.940	1.427	2,108,800	1,581,600
00	0.365	0.1045	5,220	2,600	3,555	1,750	0.403	0.940	0.910	1.309	1,672,000	1,254,000
0	0.325	0.0829	4,560	2,300	2,820	1,400	0.320	0.833	0.883	1.214	1,326,400	994,800
1	0.289	0.0657	3,740	1,850	2,235	1,100	0.253	0.744	0.860	1.137	1,051,200	788,400
2	0.258	0.0521	3,120	1,550	1,770	900	0.202	0.673	0.838	1.075	833,600	625,200
3	0.229	0.0413	2,480	1,250	1,405	700	0.159	0.613	0.820	1.024	660,800	495,600
4	0.204	0.0328	1,960	1,000	1,115	550	0.126	0.564	0.803	0.981	524,800	393,600
5	0.182	0.0260	1,560	800	885	450	0.100	0.524	0.788	0.946	416,000	312,000
6	0.162	0.0206	1,240	600	700	350	0.079	0.491	0.775	0.917	329,600	247,200

TABLE 7. COPPER WIRE—SOLID, TRIPLE BRAID WEATHERPROOFING.

Gauge A.w.g.	Ext. Diam. Inches	Area of Conductor Sq. In.	Hard-Drawn		Soft-Drawn		Load Per Lin. Ft. Vertical in Lbs.		Load Per Lin. Ft. Horizontal in Lbs. 8.0 Lbs. Per Sq. Ft. ½-in. Ice	Max. Load Per Lin. Ft. Plane of Resultant in Lbs.	Hard-Drawn EA in Lbs. E= 16,000,000 Lbs. Per Sq. In.	Soft-Drawn E×A in Lbs. (E= 12,000,000 Lbs. Per Sq. In.)
			Ultimate Tension Lbs.	Allowable Tension Lbs.	Ultimate Tension Lbs.	Allowable Tension Lbs.	Dead	Dead + ½-in. Ice				
0000	0.640	0.1662	8,310	4,150	5,650	2,800	0.767	1.476	1.093	1.837	2,659,200	1,994,400
000	0.593	0.1318	6,590	3,300	4,480	2,250	0.629	1.309	1.062	1.686	2,108,800	1,581,600
00	0.515	0.1045	5,220	2,600	3,555	1,750	0.502	1.133	1.010	1.518	1,672,000	1,254,000
0	0.500	0.0829	4,560	2,300	2,820	1,400	0.407	1.029	1.000	1.434	1,326,400	994,800
1	0.453	0.0657	3,740	1,850	2,235	1,100	0.316	0.909	0.968	1.328	1,051,200	788,400
2	0.437	0.0521	3,120	1,550	1,770	900	0.260	0.843	0.958	1.276	833,600	625,200
3	0.406	0.0413	2,480	1,250	1,405	700	0.199	0.763	0.937	1.208	660,800	495,600
4	0.359	0.0328	1,960	1,000	1,115	550	0.164	0.698	0.906	1.143	524,800	393,600
5	0.344	0.0260	1,560	800	885	450	0.135	0.660	0.896	1.113	416,000	312,000
6	0.328	0.0206	1,240	600	700	350	0.112	0.627	0.885	1.084	329,600	247,200

TABLE 8. ALUMINUM WIRE—STRANDED.

Gauge A.w.g.	Ext. Diam. Inches	Area of Conductor Sq. In.	Hard-Drawn		Load Per Lin. Ft. Vertical in Lbs.		Load Per Lin. Ft. Horizontal in Lbs. 8.0 Lbs. Per Sq. Ft. ½-in. Ice	Max. Load Per Lin. Ft. Plane of Resultant in Lbs.	E×A in Lbs. (E=9,000,000 Lbs. Per Sq. In.)
			Ultimate Tension Lbs.	Allowable Tension Lbs.	Dead	Dead + ½-in. Ice			
500,000	0.814	0.3924	9,025	4,500	0.460	1.280	1.209	1.762	3,531,600
450,000	0.772	0.3535	8,130	4,050	0.414	1.205	1.181	1.687	3,181,500
400,000	0.725	0.3141	7,225	3,600	0.368	1.130	1.150	1.612	2,826,900
350,000	0.679	0.2750	6,325	3,150	0.322	1.055	1.119	1.538	2,475,000
300,000	0.621	0.2360	5,430	2,700	0.276	0.973	1.081	1.454	2,124,000
250,000	0.567	0.1965	4,520	2,250	0.230	0.894	1.045	1.375	1,768,500
0000	0.522	0.1662	3,820	1,900	0.195	0.831	1.015	1.312	1,495,800
000	0.464	0.1318	3,160	1,600	0.155	0.755	0.976	1.234	1,186,200
00	0.414	0.1045	2,510	1,250	0.122	0.691	0.943	1.168	940,500
0	0.368	0.0829	1,990	1,000	0.097	0.637	0.912	1.112	746,100
1	0.328	0.0657	1,575	800	0.077	0.592	0.885	1.065	591,300
2	0.291	0.0521	1,250	600	0.061	0.533	0.861	1.023	468,900
3	0.261	0.0413	990	500	0.049	0.522	0.841	0.990	371,700
4	0.231	0.0328	790	400	0.039	0.494	0.821	0.958	295,200

Table 9. PROPERTIES OF WIRE MATERIAL.

	Ultimate Strength Lbs. Per Sq. In.	Elastic Limit Lbs. Per. Sq. In.	Mod. Elasticity E. Lbs. Per. Sq. In.	Coef. Expansion 1 deg. Fahr.
Copper, solid, soft-drawn	32–34,000	28,000	12,000,000	0.0000094
Copper, solid, hard-drawn	50–55–57–60,000	30–32–34–35,000	16,000,000	0.0000094
Copper, stranded, soft-drawn	34,000	28,000	12,000,000	0.0000094
Copper, stranded, hard-drawn	60,000	35,000	16,000,000	0.0000094
Aluminum, stranded	23–24,000	14,000	9,000,000	0.0000128
Steel, stranded, Siemens-Martin (Galvanized)	75,000	38,000	29,000,000	0.0000064
Steel, stranded, high tension (Galvanized)	125,000	....	29,000,000	0.0000064
Steel, stranded, extra-high tension (Galvanized)	187,000	....	29,000,000	0.0000064

(III) Specifications for Wood Poles.

(See Section 10.)

Wood poles of whatever kind shall be of sound timber, free from defects such as decay, ring shakes, loose or unsound knots or other defects which in the judgment of the Railroad will impair their strength or durability. They shall be cut above the ground swell. The butts shall be cut square and the tops roofed. The limbs and knots shall be trimmed flush.

The poles shall be specially selected to have a reasonably uniform taper and be free from short or reverse bends. Preferably the poles shall be straight, but a curvature not to exceed that given in the following table measured between the top and a point six feet from the butt will be allowed.

NATURAL POLE DIMENSIONS.

Maximum Crook Values.

(Measured between the top and a point six feet from the butt.)

	CROOK			
Length of Pole	Chestnut	Eastern White Cedar and Juniper	Western White Cedar	Yellow Pine
25	9-inch.	9½-inch.	4-inch.	4-inch.
30	9½-inch.	10-inch.	5-inch.	5-inch.
35	10-inch.	10½-inch.	6-inch.	6-inch.
40	11-inch.	12-inch.	7-inch.	7-inch.
45	11-inch.	9-inch.	7½-inch.	7½-inch.
50	11-inch.	10-inch.	8-inch.	8-inch.
55	12-inch.	11-inch.	9-inch.	9-inch.
60	13-inch.	12-inch.	10-inch.	10-inch.
65	14-inch.	....	11-inch.	11-inch.
70	15-inch.	....	....	12-inch.
75	....	....	....	12½-inch.
80	....	....	....	13-inch.

In addition to the above conditions common to all wood poles, the special requirements for various species are as follows:

Chestnut—Chestnut poles shall have been cut within two years and shall be free from butt or top rot.

Eastern and Western White Cedars shall show live timber the entire length of the surface. Dark red or copper-colored surfaces will be considered live only when good live timber shows on scraping.

No cedar pole shall have a twist greater than one complete turn in twenty feet.

Yellow Pine poles will be accepted only when treated the entire length. If sawed, the natural heart must be approximately parallel to the length of the pole.

Redwood poles shall be cut from "Number One Common" Redwood and shall have not less than ninety-six per cent. of a surface area of heartwood, with sapwood not to exceed one inch in depth at any point.

Sound knots will be accepted without limit if of diameter less than one and one-half inches. Knots between one and one-half inches and two and one-half inches will be accepted, provided there is not over one to each five square feet of surface. Knots larger than two and one-half inches will be cause for rejection of the poles.

NATURAL POLES.

The top circumference of natural poles shall be measured at the top and the butt circumference six feet above the actual butt.

Natural poles shall have the minimum circumferences specified in the following table:

Minimum Natural Pole Circumferences.

Length of Pole	Chestnut		Eastern White Cedar and Juniper		Western White Cedar		Yellow Pine	
	Top	Butt	Top	Butt	Top	Butt	Top	Butt
25 ft.	24 in.	37 in.	24 in.	36 in.	28 in.	34 in.	22 in.	33 in.
30 ft.	24 in.	40 in.	24 in.	40 in.	28 in.	37 in.	22 in.	35 in.
35 ft.	24 in.	43 in.	24 in.	43 in.	28 in.	40 in.	22 in.	38 in.
40 ft.	24 in.	45 in.	24 in.	47 in.	28 in.	43 in.	22 in.	40 in.
45 ft.	24 in.	48 in.	24 in.	50 in.	28 in.	45 in.	22 in.	42½ in.
50 ft.	24 in.	51 in.	24 in.	53 in.	28 in.	47 in.	22 in.	42½ in.
55 ft.	22 in.	54 in.	24 in.	56 in.	28 in.	49 in.	22 in.	47 in.
60 ft.	22 in.	57 in.	24 in.	59 in.	28 in.	52 in.	22 in.	49 in.
65 ft.	22 in.	60 in.	....	....	28 in.	52 in.	22 in.	49 in.
70 ft.	22 in.	63 in.	....	....	....	....	22 in.	55 in.
75 ft.	22 in.	66 in.	....	....	....	....	22 in.	55 in.
80 ft.	22 in.	70 in.	....	....	....	....	22 in.	57 in.
85 ft.	22 in.	73 in.	....	....	....	....	....	....
90 ft.	22 in.	76 in.	....	....	....	....	....	....

Sawed Pole Dimensions.

(Measurements between Parallel Faces)

Length of Pole	Redwood		Western White Cedar		Yellow Pine	
	Top	Butt	Top	Butt	Top	Butt
25 ft.	7 in.	10 in.	7 in.	11 in.	8 in.	10 in.
30 ft.	7 in.	11 in.	7 in.	12 in.	8 in.	11 in.
35 ft.	7 in.	12 in.	7 in.	13 in.	8 in.	12 in.
40 ft.	7 in.	13 in.	Sawed Western WhiteCedar shall be free of all sapwood.		8 in.	13 in
45 ft.	7 in.	14 in.			8 in.	14 in.
50 ft.	7 in.	15½ in.	....	....	8 in.	15 in.
55 ft.	....	....	....	....	8 in.	16 in.
60 ft.	....	....	....	....	8 in.	17 in.
65 ft.	....	....	....	....	8 in.	18 in.

(IV) Specifications for Galvanizing or Sherardizing on Iron and Steel.

General Description—This specification shall apply to all galvanized or sherardized material.

Coating Requirements—The coating shall consist of a continuous coating of pure zinc, zinc-iron alloy or a combination of the two, the coating to be of uniform thickness and so applied that it adheres firmly to the iron or steel. The finished product shall be smooth.

Cleaning of Samples—The sample shall be cleaned before testing, first with benzine or turpentine, using cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

Test Solution—The standard solution of copper sulphate shall consist of commercial copper sulphate crystals dissolved in cold water, about in the proportion of 36 parts by weight of crystals to 100 parts by weight of water. The solution shall be neutralized by the addition of an excess of chemically pure cupric oxide (CuO), an excess of which is shown by the sediment of this reagent at the bottom of the container. The neutralized solution shall be filtered before using, and the filtered solution shall have a specific gravity of 1.186 at 18 degrees Centigrade at the beginning of each test. This specific gravity shall be obtained by the addition of clean water, if the gravity of the filtered solution is too high, or by the addition of a filtered solution of a higher specific gravity if too low.

The unfiltered neutralized stock solution shall be replenished after each removal by the addition of more copper sulphate crystals and water. An excess of cupric oxide shall always be kept in the unfiltered stock solution.

Quantity of Solution—Wire samples shall be tested in a glass jar of not less than two inches inside diameter, filled to a depth of not less than four inches, with the standard solution without samples. Hardware samples shall be tested in a glass or earthenware jar containing not less than one-half pint of standard solution for each sample.

A new solution shall be used for each series of four immersions.

Samples—Not more than seven wires shall be simultaneously immersed and not more than one sample other than wire shall be immersed in the specified quantity of solution. Samples when immersed shall not be grouped or twisted together.

Method of Test—The samples prepared for test shall be immersed in the specified quantity of standard solution, the temperature of which shall be between seventeen and twenty degrees Centigrade throughout the test, in the following manner:

First, immerse for one minute, wash and wipe dry; second, immerse for one minute, wash and wipe dry; third, immerse for one minute, wash and wipe dry; fourth, immerse for one minute, wash and wipe dry.

The samples shall be immediately washed in clean water having a temperature of seventeen to twenty degrees Centigrade and wiped dry after each immersion.

In the case of sherardized material the specimen must be vigorously brushed in running water after each dip.

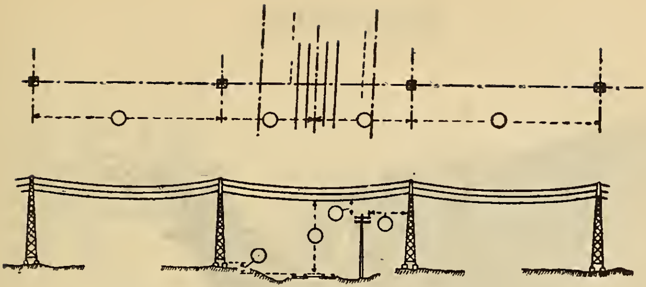
In testing wire, the No. 12 B.w.g. and smaller sizes shall be required to stand three one-minute and one one-half minute immersions. If after the test above described the samples show a bright metallic copper deposit, the lot represented by the samples shall be rejected unless the deposit is on zinc or within one inch of the cut end. If only one wire in a group of seven simultaneously immersed shall fail, or if there is reasonable doubt of the copper deposit, two check tests shall be made upon these lots, and the report based upon the majority of the sets of tests.

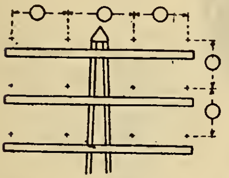
In case the article is threaded, the thread shall be clean and true after galvanizing or sherardizing and shall stand at least one immersion in the test solution.

Inspection—All material shall be inspected on receipt; samples shall be taken at random and submitted to tests hereinabove specified. The shipment will be accepted or rejected upon these samples.

Rejection—Any material which fails to meet the requirements hereinbefore specified may be rejected and returned at the expense of the Contractor.

Methods of Shipment—All material furnished under these specifications shall be so packed for shipment that it will be suitably protected from injury. Each package shall be plainly marked, giving the kind of material and the number of the Railroad's order on which shipment was made.





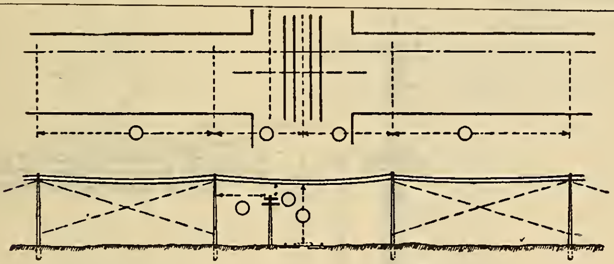
Note:-
Fill in dimensions indicated thus ○

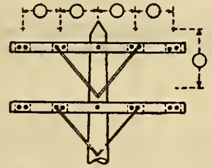
÷ DATA ÷

Number of wires
Gauge of wires
Material of wires
Solid or stranded
Bare or insulated
Hard or soft drawn
Voltage
Maximum stress in wires
Type of insulator
Catalogue number of insulator
Catalogue number of pin
Type of conductor attachment

TYPICAL CROSSING OF STEEL POLE LINE

Diagram A





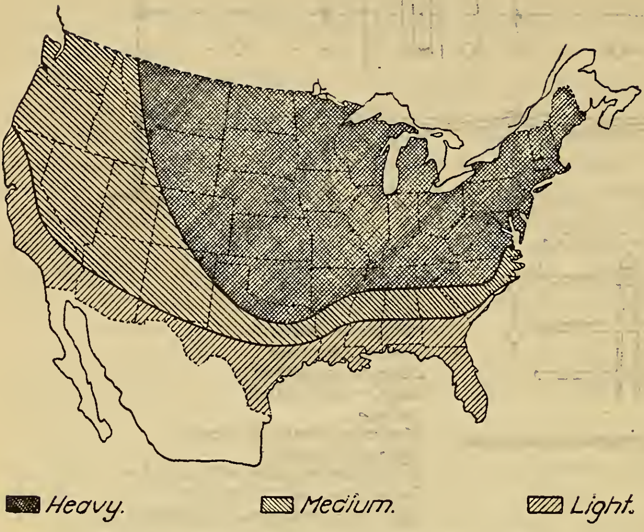
Note:-
Fill in dimensions indicated thus ○

+ CATA +

Number of wires
Gauge of wires
Material of wires
Solid or stranded
Bare or insulated
Hard or soft drawn
Voltage
Maximum stress in wires
Type of insulator
Catalogue number of insulator
Catalogue number of pin
Type of conductor attachment
Diameter of poles at ground lines
Soecies of timber
Size of cross-arms
Size and material of guys
Angle between poles and guys
Detail of guy connection
Details of guy ancnorages
Type of strain insulator

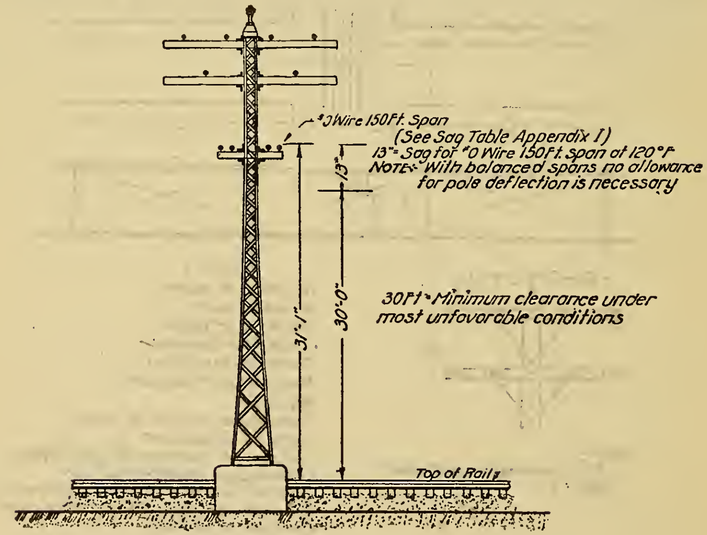
TYPICAL CROSSING OF WOODEN POLE LINE.

Diagram B



U.S. DISTRICT LOADING MAP—SECTION 5
BUREAU OF STANDARDS

Diagram C

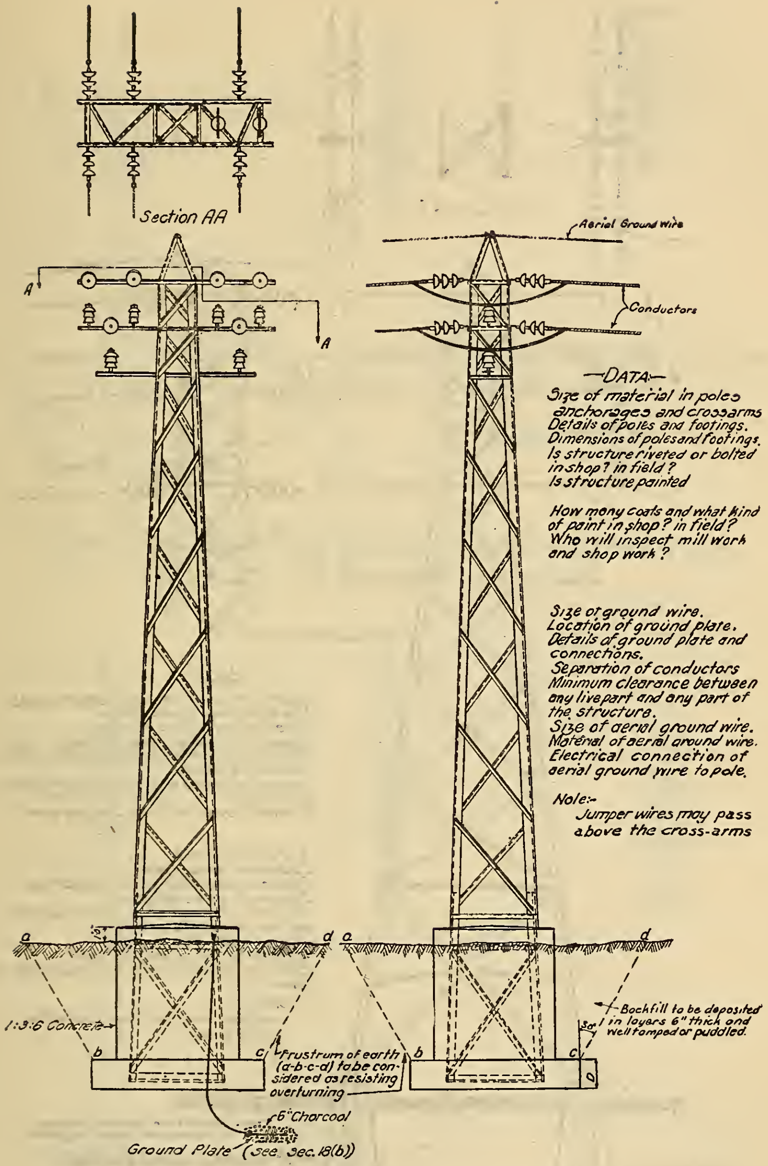


#0 Wire 150 Ft. Span
(See Sag Table Appendix I)
13" = Sag for #0 Wire 150 Ft. Span at 120° F
NOTE:— With balanced spans no allowance for pole deflection is necessary

30 Ft. Minimum clearance under most unfavorable conditions

DETERMINATION OF HEIGHT OF CONDUCTOR SUPPORTS—SECTION 4 (a).

Diagram "D"



Frustrum of earth (a-b-c-d) to be considered as resisting overturning

Backfill to be deposited in layers 6" thick and well tamped or puddled.

—DATA—

Size of material in poles anchorages and crossarms
Details of poles and footings.
Dimensions of poles and footings.
Is structure riveted or bolted in shop? in field?
Is structure painted

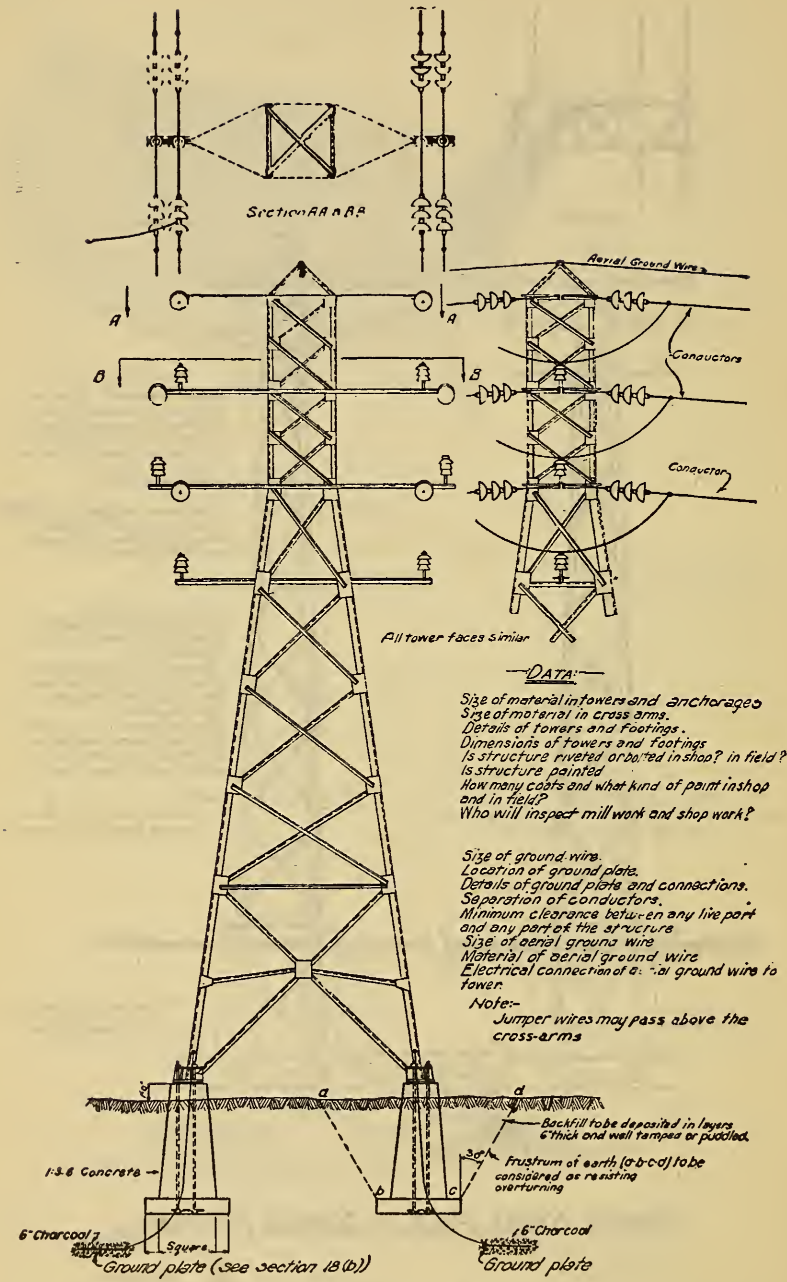
How many coats and what kind of paint in shop? in field?
Who will inspect mill work and shop work?

Size of ground wire.
Location of ground plate.
Details of ground plate and connections.
Separation of conductors
Minimum clearance between any live part and any part of the structure.
Size of aerial ground wire.
Material of aerial ground wire.
Electrical connection of aerial ground wire to pole.

Note:-
Jumper wires may pass above the cross-arms

TYPICAL STEEL POLE & SINGLE FOOTING

Diagram E


Section AA & BB
A
A
B
B
Aerial Ground Wire
Conductors
Conductor
All tower faces similar
1'0"
a
d
b
c
30°
Backfill to be deposited in layers 6" thick and well tamped or puddled.
Frustrum of earth (a-b-c-d) to be considered as resisting overturning
1:3:6 Concrete
6" Charcool
6" Charcool
Square
Ground plate (see section 18(b))
Ground plate

—DATA:—

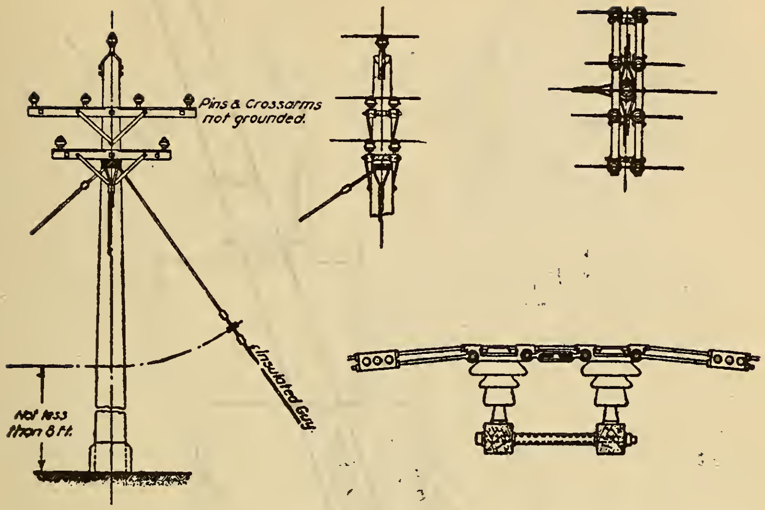
Size of material in towers and anchorages
Size of material in cross arms.
Details of towers and footings.
Dimensions of towers and footings
Is structure riveted or bolted in shop? in field?
Is structure painted
How many coats and what kind of paint in shop and in field?
Who will inspect mill work and shop work?

Size of ground wire.
Location of ground plate.
Details of ground plate and connections.
Separation of conductors.
Minimum clearance between any live part and any part of the structure
Size of aerial ground wire
Material of aerial ground wire
Electrical connection of aerial ground wire to tower.

Note:-
Jumper wires may pass above the cross-arms

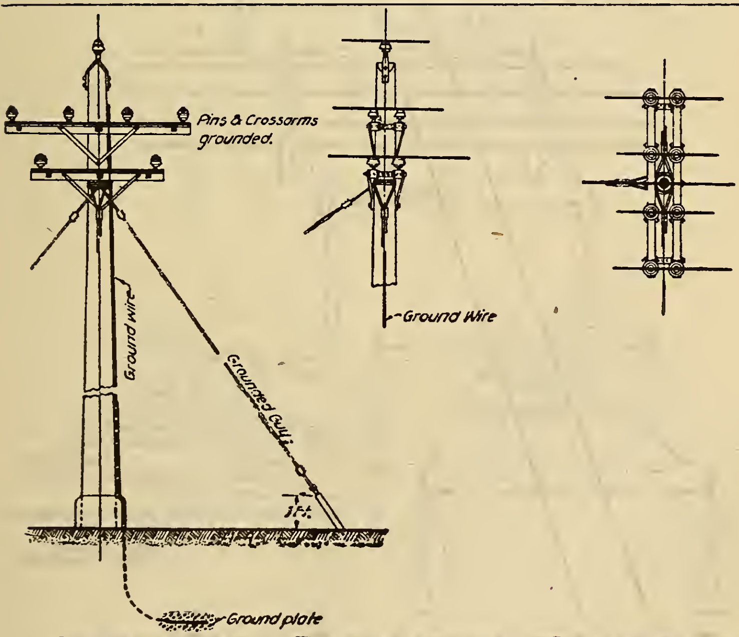
TYPICAL STEEL TOWER & MULTIPLE FOOTING.

Diagram F.



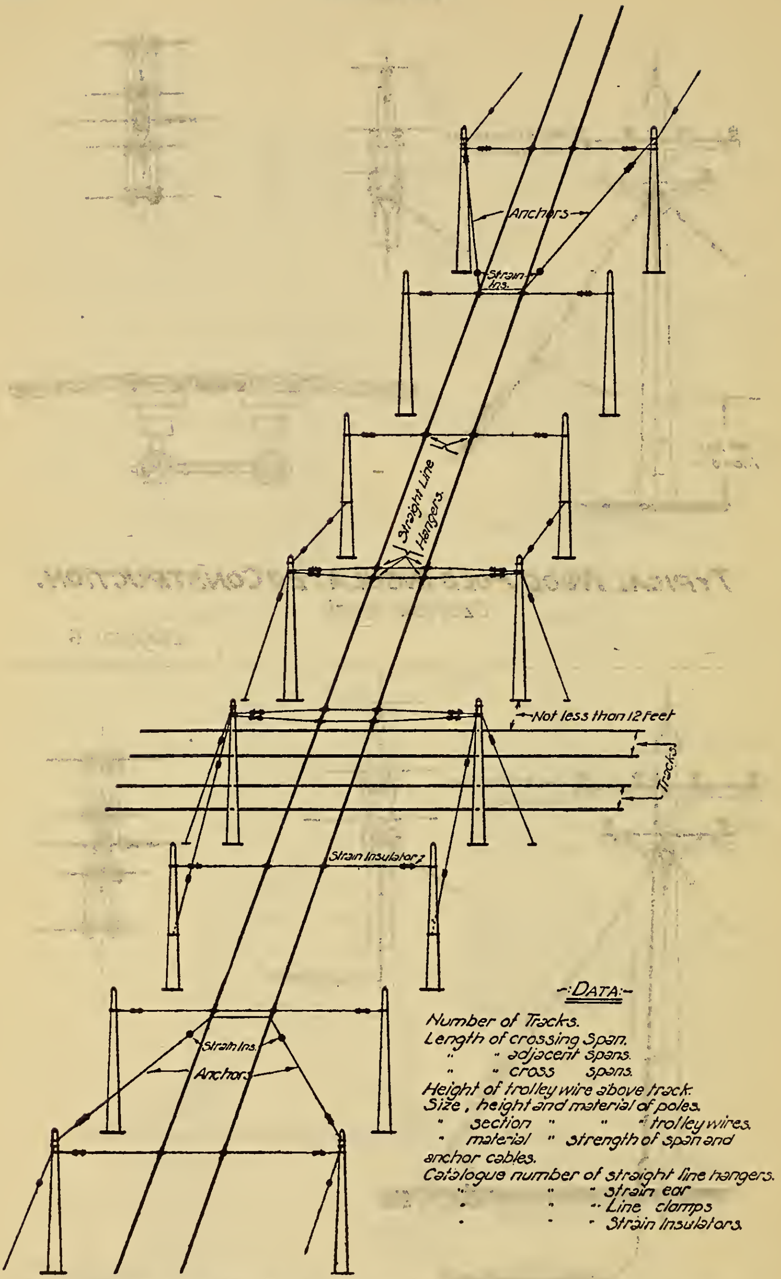
TYPICAL WOOD POLE INSULATED CONSTRUCTION.
SECTION 18(a)

Diagram G



TYPICAL WOOD POLE GROUNDED CONSTRUCTION
SECTION 18(a)

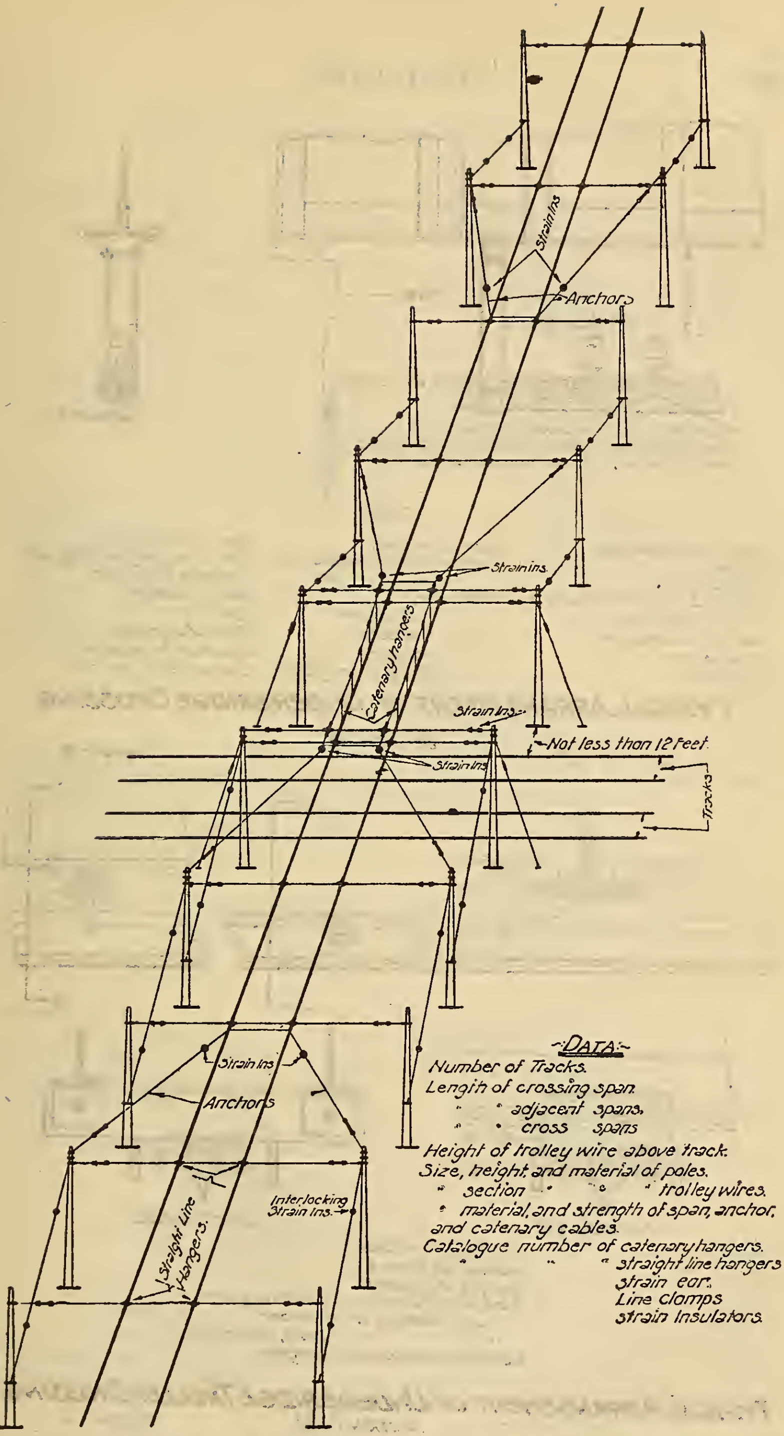
Diagram.H.



-:DATA:-

Number of Tracks.
Length of crossing Span.
" " adjacent Spans.
" " cross spans.
Height of trolley wire above track.
Size, height and material of poles.
" section " " " trolley wires.
" material " strength of span and anchor cables.
Catalogue number of straight line hangers.
" " " strain ear
" " " Line clamps
" " " Strain Insulators.

TYPICAL ARRANGEMENT OF TROLLEY CROSSING.
For spans not exceeding 100 feet Section 19
Diagram 1

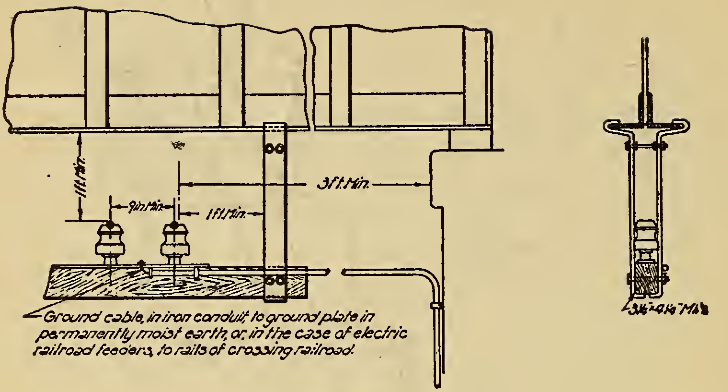


-:DATA:-

Number of Tracks.
Length of crossing span.
" " adjacent spans.
" " cross spans
Height of trolley wire above track.
Size, height, and material of poles.
" section " " trolley wires.
" material, and strength of span, anchor, and catenary cables.
Catalogue number of catenary hangers.
" " " straight line hangers
strain ear.
Line clamps
strain Insulators.

TYPICAL ARRANGEMENT OF TROLLEY CROSSING.
For spans exceeding 100 Feet Section 19

Diagram J.



—Ground cable, in iron conduit to ground plate in permanently moist earth, or, in the case of electric railroad feeders, to rails of crossing railroad.

—:Data:—

Number of conductors.
Size of "
Material of "
Solid or Stranded Conductors
Hard or soft drawn "
Kind of insulation on "
Thickness of " " "
Voltages.

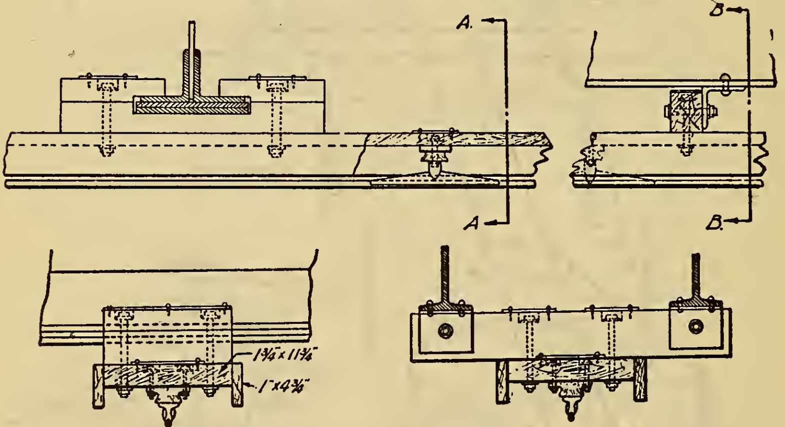
Type of insulator.
Catalogue number of insulator.
" " " pin.
Material of pin.
" " Crossarm.
Size of Crossarm.
" " Hanger
" " Xarm grounding plate

Size of ground wire
Kind " insul. on grounding wire
Thickness of insul. on " "
Kind of conduit.
Size " "
Type of bushing.
Location of ground.
Character of ground.

TYPICAL ARRANGEMENT OF UNDERBRIDGE CROSSING.

SECTION 26

Diagram K.



SECTION A-A.

SECTION B-B.

—:Data:—

Number of tracks.
Spacing of supports.
Size, section and material of trolley wires.
" and material of all lumber
" " " " " bolts, rivets, Etc.
Catalogue number of hangers.

TYPICAL ARRANGEMENT OF UNDERBRIDGE TROLLEY CROSSING.

SECTION 23(b)

Diagram L.

Index to Specifications for Wire Line Crossings.

A

Section No.

Adjacent Poles, Foundations for...........7(d)
“ “ Guying of.........22(b)-24(b)
“ “ Location....................8
“ Spans, Broken Wires.........5(c)-(d)
“ “ Dead-ended................15
“ “ Load on Supports.........5(e)
“ “ Location....................8
“ “ With Pin Insulators......13(b)
“ “ Working Stresses............6
Aerial Ground Wires, General............15(d)
“ “ “ Loading...........15(b)
“ “ “ on Steel and Wooden Poles............18(c)
“ “ “ Working Stresses....6(d)
Alteration of Drawings..................2(a)
Anchorages, Guy.........................16
Anchor Rod..............................16
Anchors, Trolley Lines................21(b)-24
Angles, Minimum Thickness and Size.....9(d)
Application for Crossing Permits..........2(a)
Approval of Drawings................... 2(a)
Artificial Grounds......................18(b)

B

Back Filling............................7(f)
Beginning Field Work....................2(b)
Bolts in Steel Work.....................9(i)
Bolts, Field and Countersunk Rivets, Working Stresses........................6(c)
Bracket Arms..........................23(e)
Broken Wires (see Table III)...........14-5(e)
Buoyancy of Submerged Foundations.....7(a)

C

Catenary Spans....................19(b)-23(f)
Caps on Trolley Poles......................23
Charcoal around Ground Plates..........18(b)
Clamps at Insulators......................14
Clearing about Poles.....................2(g)
Clearances..............................4-21
“ Between Pole Lines............4(b)
“ “ Conductors (See Table II).......4(e)
“ “ Poles and Tracks......4(c)
“ From Bridges and Buildings....4(d)
“ “ Supports (seeTable II)....4(f)
“ Supply Lines above Rails 4(a)-5(e)-14
“ Trolley Lines above Rails........20
“ Underbridge.....................21
“ Underground.....................26
Compression Members, Steel..............9(e)
Concrete, Encasing Wood Poles..........10(b)
“ Filling of Pockets..............9(c)

C

Section No.

Concrete, In Anchorages....................16
“ In Foundations..............7(b)-(c)
“ Weight of.......................7(a)
“ Working Stresses................6(e)
Conductors, Clearances..............4-20-25-26
“ Material, Size, Stranding....15(b)
“ Working Stress...............6(d)
Conduit.................................26
Creosoted Lumber.......................6(g)
Cribbing...............................7(e)
Crossing Spans (see Spans).
Cross-Arms, Bridles for Large Wires......5(d)
“ Grounding, also Diagram K............18(a)-25
“ Loading.......................5(d)
“ Materials and Construction (See Diagrams).............11
“ Underbridge (Diagram K).....25

D

Definitions..............................2(j)
Deflection of Poles...................4(a)-5(e)
Defective Material........................2(c)
Deterioration of Wood.....................6(b)
District Loading Map (Diagram C).......5(a)
Drawings ....2(a)-16
Drilling or Cutting of Bridges.....25(d)

E

Electric Light Lines.........................3
Elevation of Wires at Insulators...........4(a)
Elongation of Wires.......................5(e)

F

Fire Hazard..............................2(f)
Foundations, Buoyancy.....................7(a)
“ In Swampy Ground......7(a)-(d)
“ Steel Poles and Towers.7(a)-23(a)
“ Wooden Poles and Towers....10(b)-(c)-7(d)-(e)-(f)

G

Galvanizing.........................2(l)-9(k)
Galvanized Iron Pipes....................18(b)
Gates at Crossings.......................19(b)
General............................2-4(a)-19
Grass near Poles..........................2(f)
Ground Plates............................18(b)
Ground Wires.............................18(e)
Grounding................................18(b)

INDEX—Continued

G

Section No.

Grounding, Artificial Grounds..........18(b)
  " High Tension Trolley Crossings.24
  " of Cross-Arms and Pins
    (See Diagram K)..........18(a)
  " of Steel Poles and Towers.....18(a)
  " of Wooden Poles and Towers..18(a)
  " Underbridge Cross-Arms
    (See Diagram K)..........18(a)
Guards, for Trolleys................19(b)-22
Guys..............................17-23(b)
  " Anchorages..........................16
  " Attachment to Poles...............17(b)
  " Grounding.........................18(d)
  " Guards............................17(d)
  " Insulators in.................18(d)-17(c)
  " Loading............................5(f)
  " Material and Strength..............17(a)
  " To Trolley Poles...................21(a)
  " To Wooden Poles....................10(d)
  " Wooden Braces......................17(a)

H

High Potential Tests of Insulators........13(c)
  " " Trolleys......................24

I

Ice, Thickness and Weight............5(b)-(e)
Identification of Poles....................2(e)
Inflammable Material about Poles.........2(f)
Inspection, Inspector............2(c)-9(c)-10(c)
Interpretation of Drawings and
  Specifications..........................2(c)
Insulated Trolley Guards..........19(b)-22(b)
Insulation of Ground Wires...............18(c)
Insulators, Line............................13
  " Material and Construction.13(a)-(c)
  " Number used................13(b)
  " Specifications for Testing......13(c)
  " Tests, Formulas, Table.......13(c)
  " Types, Disc, Pin and
    Suspension..................13(b)
  " Wet Test Defined.............13(c)
  " Strain.......................13(d)
  " " In Bracket Construction 23(e)
  " " In Bridles...............5(d)
  " " In Trolley Spans........23(d)
  " " In Guys................17(c)
  " " Tests..................13(d)

J

Joints..............................15(a)-21(c)
Jumpers...................................15(a)

L

Section No.

Latticed Structures, Loading..............5(e)
Loading Conditions............................5
  " District, Loading Map
    (Diagram C)..................5(a)
  " Of Cross-Arms..................5(d)
  " Of Guys........................5(f)
  " Of Pins and Insulators............5(c)
  " Of Poles and Towers.............5(e)
  " Of Wires and Cables..........5(a)-(b)
Location of Poles or Towers.........2(f)-4(c)-8

M

Maintenance of Crossings.............2(b)-6(h)
Marking of Poles...........................2(e)
Messenger Wires...........................5(b)

N

National Electrical Safety Code...........2(j)
Notices...................................2(b)

P

Painting, Guy Guard......................17(d)
  " Of Steel....................9(c)-(k)
Patented Devices..........................2(d)
Permit from Railroad and other
  Permits......................2(a)-(b)-23(f)
Pins, Material...............................12
Poles (see Wooden Poles or Steel Poles)
Pole Deflection...........................4(a)
  " Loading...............................5(c)
Power Supply Lines............................3
Preservative Treatment of Poles.........10(b)

R

Riprap....................................7(a)
Rivets, General Clause....................9(h)
  " Material.......................9(b)
  " Size of Holes..................9(d)
  " Spacing........................9(g)
  " Working Stress..............6(b)-(c)
Rubbish Removed...........................2(g)

S

Sags, Sag Table (see Appendix 1)..........4(a)
  " Minimum Sags......................15(a)
Self-Supporting..................5(f)-9(a)-22(b)
Separation of Conductors (see Table 1)....4(e)
Sherardizing (Appendix III).........2(b)-9(k)

INDEX—Concluded

S

Section No.

Side Clearance....................4(b)-(c)-(d)
Signal Lines................................3
" " Clearance above other Lines..4(b)
" " Crossing over and under other Lines......................15(c)
" " Loading..........................5
" " Maintenance..............2(i) 6(h)
" " Working Stresses..........6(d)-(f)
Signs....................................2(e)
Spans.....................................15
" Cradles or Overhead Bridges.......15(a)
" Dead Ending (Diagrams E and F) .15(a)
" Length of......................15(a)-9(b)
" Minimum Sags (Appendix I)........15(a)
" Splicing.......................15(a)-22(c)
" Tension of Wires...................15(a)
" Trolley Crossing Spans.............19(b)
" Trolley Span Wires.................23(c)
Specifications, Concrete.................7(b)
" Galvanizing and Sherardizing.............2(h) (Appendix IV)
" Insulator Testing A.I.E.E. 13(c)
" Interpretation of...........2(c)
" Structural Steel............9(b)
" Wooden Poles.............10(a) (Appendix III)
Strain Insulators (see Insulators)
Steel Poles or Towers.........................9
" " " Bolts.................9(i)
" " " Compression Members.........9(e)
" " " Eccentricity and Splicing...........9(f)
" " " Foundations7(a)-(d)-23(a)
" " " Galvanizing (Appendix IV) ....9(k)
" " " Minimum Thickness Metal.............9(d)
" " " Of Tubular Steel......23
" " " Painting and Sherardizing...9(c)-(k)
" " " Protective Sleeve for Trolley Poles.....23(a)
" " " Riveting(see Rivets)9(h)
" " " Self Supporting......9(a)
" " " Spacing of Rivets....9(g)
" " " Steel Specifications..9(b)
" " " Straightening and Finishing..........9(j)
" " " Strength 9(c)-6(a)-(b)-(c)
" " " Workmanship.......9(c)
Structural Steel, Specifications for........9(b)
" " Stresses...................6(a)
Struts Replacing Guys.............5(a)-17(a)

T

Section No.

Taps to Conductors.....................15(a)
Telegraph and Telephone Lines (see Signal Lines)
Temperature....................4(a)-5(b)-(e)-6(g)
Terminology..................................2(j)
Tests, By Inspector.........................2(c)
" Of Insulators.......................13(c)
" Of Steel Poles or Towers............9(c)
Tie Wires....................................14
Treated Wood................................6(g)
Trolley Feeders, Clearances..................20
" Guards.......................19(b)-22
" Line Crossings, L. T. and H. T...19-24
" Wire, Clearance.....................20
" " Material and Size..............21
" " Splicing....................21(c)
" " Uniformity of Height...19(b)-(c)

U

Underbridge Crossings..................25(a)-(d)
Underbrush near Poles.......................2(f)
Underground Crossings.......................27
Untreated Wood.............................6(f)

W

Warning Signs..............................2(c)
Weather Bureau Reports.....................5(a)
Weight of Earth and Concrete...........7(a)
" of Ice...........................5(h)
Wind Loadings........................5(b)-(e)
Wood Deterioration.........................6(h)
Wooden Poles................................10
" " Concrete Setting............10(b)
" " Grounding on...........18(a)-(d)
" " Head and Side Guys.......10(d)
" " In Swampy Ground.........7(d)
" " Maintenance.................6(h)
" " Preservative Treatment—Creosoting..........10(b)-6(g)
" " Setting (see Table VII).....10(c)
" " Specifications(Appendix III)10(a)
" " Working Stresses.........6(f)-(g)
" Cross-Arms, Size and Number (Diagrams G and H)........5(d)-11
Working Stresses.............................6
" " Bolts, Field and Countersunk Rivets............6(c)
" " Concrete.................6(e)
" " In Maintenance..........6(h)
" " Rivets and Pins..........6(b)
" " Structural Steel...........6(a)
" " Treated Wood......6(g)-10(b)
" " Untreated Wood..........6(f)
" " Wires and Cables........6(d)

[5] STONE CONDUITS.

1. Material.

Stone conduit shall be made of limestone screenings which will pass through a screen of one-eighth (⅛) in. mesh and approved make of Portland cement in the proportion of four and three-quarters (4¾) to one (1) properly moistened with water and shall be formed by tamping in cylindrical moulds.

2. Dimensions.

Conduit shall be made in lengths of five (5) feet with five-eighths (⅝) in. walls and three and one-half (3½) to four and one-half (4½) in. round bore.

3. Workmanship.

(a) Conduit shall be symmetrical throughout, straight, true, smooth, free from cracks, air holes, uneven surfaces or other imperfections which will injuriously affect it. The ends shall be perpendicular to the bore.

(b) Conduit shall be cured for not less than eight (8) weeks after removal from the mould. For the first six (6) weeks it shall be kept wet by sprinkling and then allowed to dry in the air for at least two (2) weeks.

4. Joints.

(a) Conduit when thoroughly cured shall be turned, for a distance of three-quarters (¾) of an inch on each end, sufficient to secure an exact diameter concentric with the bore, but which shall not reduce the thickness of the wall given in Section 2 by more than one-sixteenth (1/16) of an inch.

(b) With each conduit there shall be supplied a suitable metal sleeve which will fit tightly over the ends of adjacent conduits to hold them in place and to secure perfect alinement.

5. Short Lengths.

Pieces of conduit less than the standard five feet length will be accepted, not to exceed 10 per cent. of the total ordered, provided the ends are cut square, dressed and turned for metal sleeves, but no conduit will be accepted less than two and one-half (2½) ft. long.

6. Inspection.

(a) The Railroad may inspect the conduit at any time during the process of manufacture and shall be furnished free of cost the necessary tools and appliances for making such tests as are necessary to determine if the requirements of these specifications have been met.

(b) Conduit offered for inspection shall be factory run from which no conduit of a superior quality has been removed.

(c) The Railroad shall be given advance notice of completion of conduit to permit it to arrange for inspection.

---

[5] Adopted, Vol. 22, 1921, pp. 140, 970.

7. Tests.

(a) Conduits shall permit the passage from end to end of a mandrel three (3) ft. long and one-eighth (⅛) in. less than the nominal diameter of the bore.

(b) Samples of five (5) ft. lengths of conduit shall be selected at random and after immersion for twenty-four (24) hours in air shall show an increase in weight of not more than nine-tenths (9/10) of one per cent.

(c) The presence of cracks shall be determined by sounding each piece with a steel hammer or its approved equivalent. Pieces which fail to give a clear metallic ring shall be considered defective.

(d) Conduit which fails to meet all of the requirements of these specifications shall be rejected.

8. Installation.

(a) Conduit line shall be encased in concrete four (4) in. thick on top, three (3) in. on the sides and a minimum thickness of four (4) in. for the full width of the trench, except where ledge rock is encountered; in which case the concrete foundation may be omitted and the bottom of the trench leveled with cement mortar. Conduits shall be laid with a minimum separation of one (1) in. both horizontally and vertically and the joints shall be staggered so that the joints of adjacent sections will be separated by at least three (3) in.

(b) In ending conduits only full lengths shall be used in the lower tier at the entrance to splicing chambers. Short lengths where necessary shall be inserted further out in the section.

(c) Where work is suspended leaving incompleted sections the open ends of the conduits shall be plugged with tapered wood, or other approved plug conforming accurately to the shape of the bore and so formed that it cannot be forced entirely within the opening.

(d) During construction work a mandrel three (3) ft. long and one-eighth (⅛) in. less than the nominal bore shall be drawn through the conduits as they are laid.

(e) In other respects the methods of laying stone conduits shall correspond to the American Railway Engineering Association Specifications for Fiber Conduits.

[6] RAILWAY SPECIFICATIONS FOR ELECTRIC WIRES AND CABLES.

Table of Contents.

1. Scope.
2. Inspection.
3. Notification.
4. Tests.
5. Rejection.
6-A. Wrapping.
7. Marking.
8. Terminology.
9. Lot.
10-25. (Omitted).

---

[6] Adopted, Vol. 22, 1921, pp. 147, 969.

General Construction.

26. Area and Material of Stranded Conductors.
27. Stranding.
27-A. Repairs of Insulation.
28. Triplex, Duplex and Twin Cables.

Soft or Annealed Copper Wire and Cable.

29. General.
30. Shape.
31. Surface Imperfections.
32. Specific Gravity.
33. Permissible Variations from Dimensions.
34. Gaging.
35. Elongation.
36. Conductivity.
37. Tinning.
38. Joints.
39. Packing and Shipping.

Hard Drawn Copper Wire and Cable.

41. General.
42. Shape.
43. Surface Imperfections.
43-A. Specific Gravity.
44. Core.
45. Permissible Variations from Dimensions.
46. Brazes.
47. Conductivity.
48. Extensometer Test.
49. Tensile Strength and Elongation.
50. Tensile Strength of Cables.

Class A Rubber Insulation with Mineral Base.

52. Constituents.
53. Results of Analysis.
54. Check Analysis.
55. Concentric Application.
56. Thickness of Insulation.
57. Elasticity.
58. Tensile Strength.
59. Electrical Tests.

Varnished Cloth Insulation.

60. Description.
61. Thickness of Insulation.
62. Filler.
63. Assembly.
64. Tape.
65. Electrical Tests.

Impregnated Paper Insulation.

66. Description.
67. Thickness of Insulation.
68. Tensile Strength.
69. Electrical Test.

Electrical Tests of Insulation at Factory.

70. High Potential Test.
71. Insulation Resistance.

Separator.

72. Separator.

Rubber Filled Cloth Tape.

73. Tape.

Braid.

74. Weatherproof Braid.
75. Tests.
76. Circular Loom Braid.

Dry Paper Tape.

77. Dry Paper Tape.

Miscellaneous Braids.

78. Glazed Cotton Braid.
79. Hemp Braid.
80. Colored Braid.
80-A. Flameproof Braid.

Lead Sheath.

81. Composition.
82. Thickness.

Galvanized Steel Wire Armor.

83. General.
84. Preparation for Armor.
  (a) Cloth, Taped or Braided Cables.
  (b) Lead Sheathed Cables.
85. Thickness of Jut Bedding.
86. Armor Wire.
87. Application of Armor.
88. Covering over Armor.
89. Direction of Lay.
90. Size of Wire.
91. Samples for Test.
92. Tensile Strength and Elongation.
93. Galvanizing.
94. Flexibility.
96. Armor Tape.
98. Coating.
99. Cleaning.
100. Test.
101. Quality of Solution.
102. Results of Tests.

Enameled Copper Magnet Wire.

105. Preparations for Shipping.
107. Form of Reel.
108. Bushing.
110. Covering and Lagging.
111. Marking.
112. Chocking.

List of Tables in Specification.

Table No.
I. Standard Stranding of Concentric-Lay Cables.
II. Stranding of Flexible Cables.
III. Packages of Bare Soft or Annealed Copper Wire.
IV. Elongation of Soft or Annealed Copper Wire.
V. Conductivity of Soft or Annealed Untinned Copper Wire.
VI. Conductivity of Soft or Annealed Tinned Copper Wire.
VII. Tensile Strength and Elongation of Hard Drawn Copper Wire.
VIII. Thickness of Rubber Insulation.
IX. Elongation and Permanent Set of Grade A Rubber Compound.
X. Thickness of Varnished Cambric Insulation.
XI. Thickness of Impregnated Paper Insulation.
XII. Test Potentials for Rubber Insulation.
XIII. Test Potentials for Varnished Cloth and Impregnated Paper.
XIV. Megohm-Miles at 15.5 deg. Cen. (60 deg. Fahr.)
XV. Temperature Coefficients for Resistance of Rubber Compound.
XVI. Width and Overlap of Rubber Filled Cloth Tape.
XVII. Thickness of Cotton Braid.
XVIII. Thickness of Sheath.
XIX. Size of Steel Armor Wire.
XX. Size of Steel Tape and Juts for Armoring Cables.

RAILWAY SPECIFICATIONS FOR ELECTRIC WIRES AND CABLES.

GENERAL.

1. Scope.

(a) The purpose of these specifications is to describe wires and cables to be used principally for electric lighting, power transmission, and electric traction purposes.

(b) The workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best modern engineering practice.

(c) Provisions in subsidiary specifications which are contrary to these specifications annul the corresponding provisions in these specifications.

2. Inspection.

(a) The wires and cables will be inspected by the Engineer of the Railroad or his authorized representative, who shall be afforded all necessary facilities to ascertain whether the material and processes conform to these specifications.

(b) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for eighteen hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

Dry core paper insulated lead covered cables, such as telephone and telegraph cables, for use in water shall be tested after eighteen hours immersion.

(c) In multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test will be made on finished cables, but only on the individual conductors before assembling.

(d) Submarine cables shall be given a final test by immersing the completed cable in water in addition to the immersion test upon the individual conductors. (See Section 59-a.)

(e) All other wires and cables will be inspected in their completed form.

(f) The Inspector will notify the Manufacturer in writing when the preliminary tests are satisfactory. Additional covering applied previous to the receipt of such notice will be at the Manufacturer's risk.

(g) Wires and cables shall not be shipped without being sealed by the Inspector unless permission is given in writing.

The seals are applied for identification purposes only, and shall not be considered by the Manufacturer as evidence of acceptance.

3. Notification.

The Manufacturer shall notify the Railroad sufficiently in advance of the completion of the wires or cables to permit arrangements to be made for the presence of an Inspector.

4. Tests.

The Manufacturer shall furnish suitable facilities for the testing of the wires and cables and shall make the specified tests in the presence of the Inspector. The Manufacturer shall also afford the Inspector every other reasonable facility to ascertain whether the requirements of these specifications have been complied with.

The Railroad will make chemical analysis of the rubber compound or other materials entering into the manufacture of the wires and cables whenever it deems such a step necessary.

When the Railroad desires bending or other mechanical or electrical tests not herein specified, they will notify the Manufacturer and the test shall conform to the requirements of the American Institute of Electrical Engineers.

Except where otherwise specified the results of tests will determine the acceptance of the individual coil or reel on which tests were made.

5. Rejection.

If rejections exceed 20 per cent. of the length offered for inspection at one time, the expense of inspection and test of the rejected part shall be borne by the Manufacturer. Freight charges on foreign lines for the return of all wires or cables that may be found defective and rejected after receipt by the Railroad shall be borne by the Manufacturer.

The Railroad may make tests of samples of the wire or cable in its own laboratory or elsewhere, but such tests shall be made at its own expense.

The Manufacturer may retain duplicate sealed samples and, in case of dissatisfaction, may demand a check test upon such sealed samples at any time within two weeks after the date of the test report. (See Section 54.)

6. Patents.

The Manufacturer shall defend and save harmless the Railroad from, and indemnify it against any and all claims which may be made against it on account of alleged infringements of patent rights, and expenses of any kind in connection therewith, arising from the use of the wire or cable furnished by the Manufacturer.

6-A. Wrapping.

Wires and cables shall be securely wrapped as follows:

Package	*Style of Wire or Cable*	*Wrapping*
Coil	National Electric Code.	Paper or Burlap.
	Any but Code.	Burlap.
Spool	Any.	Paper or Burlap and boxed in a manner satisfactory to the Inspector.
Reel	All.	See Section 110.

7. Marking.

Where wires or cables are shipped in coils or on spools, a tag containing the following information shall be securely attached to the coils or spools and a similar tag fastened to the outside of the wrapping: (a) name of Manufacturer, (b) size of wire or cable, (c) character of insulation, (d) net pounds, (e) gross pounds, (f) number of feet, (g) Railroad's requisition and order number.

8. Terminology.

The terminology used in these specifications is that recommended in the Standardization Rules of the American Institute of Electrical Engineers.

9. Lot.

The word lot shall be understood to refer to all of the wires of one kind and size offered for inspection at one visit of the Inspector.

GENERAL CONSTRUCTION.

26. Area and Material of Stranded Conductors.

(a) *Sectional Area of Cables*—The cross-sectional area of cables shall be considered to be the sum of the cross-sectional area of its component wires when measured perpendicular to their axis and shall be not less than the specified circular mils or area corresponding to the specified gage. (See Section 33.)

(b) *Annealing*—Unless otherwise specified, conductors shall be of soft or annealed copper.

27. Stranding.

Unless otherwise specified, the stranding of cables shall be concentric, with successive layers wound in opposite directions.

The cables shall have not less than the number of wires specified in Table I or Table II for the type of cable ordered, but cables having a greater number of wires will be accepted.

TABLE I—STANDARD STRANDING OF CONCENTRIC-LAY CABLES.

Size (See Note 1)	Number of Wires (See Note 2)		Size (See Note 1)	Number of Wires (See Note 2)	
	A Bare, Insulated or Weatherproof Cables for Aerial use.	B Insulated Cables for other than Aerial use.		A Bare, Insulated or Weatherproof Cables for Aerial use.	B Insulated Cables for other than Aerial use.
2.0 Cir. Inches.	91	127	0000 A. W. G...	19 or 7 (See Note 3)	19
1.5 " " .	61	91			
1.0 " " .	61	61	00 " ...	7	19
			2 " ...	7	7
0.6 " " .	37	61			
0.5 " " .	37	37	7 and smaller...	....	7
0.4 " " .	19	37			

1. For intermediate sizes, use stranding for next larger size.

2. Conductors of 0000 A. W. G. and smaller are often made solid and this table of stranding should not be interpreted as excluding this practice.

3. Class A cable, sizes 0000 and 000 A. W. G., is usually made of 7 strands when bare and 19 strands when insulated or weatherproof.

Table II—Stranding of Flexible Cables

Size	No. of Wires	Size of Each Wire A.W.G	Make-up. (See Note 1)	Size	No. of Wires	Size of Each Wire A.W.G	Make-up (See Note 1)
2039000...	703	15.5	37 x 19	000......	133	19.0	19 x 7
1816000...	"	16.0	"	00......	"	20.0	"
1617000...	"	16.5	"	0......	"	21.0	"
1440000...	"	17.0	"	1......	91	20.5	Concentric
1284000...	"	17.5	"	2......	"	21.5	"
1103000...	427	16.0	61 x 7	3......	"	22.5	"
874600...	"	17.0	"	4......	61	22.0	"
693600...	"	18.0	"	5......	"	23.0	"
550000...	"	19.0	"	6......	"	24.0	"
436200...	"	20.0	"	8......	"	25.5	"
345900...	"	21.0	"	10......	37	25.5	"
274300...	"	22.0	"	12......	"	27.5	"
264600...	259	20.0	37 x 7	14......	"	29.5	"
0000...	"	21.0	"				
Smaller...	To Equal Required Size	30.0	Bunched	Smaller..	To Equal Required Size	30.0	Bunched

Note 1. "61x7" in the description of a rope-lay cable signifies 61 strands of 7 wires each.

27-A. Repairs of Insulation.

If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repaired part or joint, and all parts affected by it, as strong and durable electrically, as the remainder of the insulation. In the case of rubber insulation the patches shall be properly vulcanized.

28. Triplex, Duplex and Twin Cables.

Unless otherwise specified the conductors of duplex or triplex cables shall be twisted and filled out to make round. Twin cables shall have their conductors laid parallel.

SOFT OR ANNEALED COPPER WIRE AND CABLE.

29. General.

The purpose of these specifications is to secure soft or annealed copper wire of the best commercial quality.

30. Shape.

The wire shall be of circular cross-section unless otherwise specified.

31. Surface Imperfections.

The wires shall be free from all surface imperfections not consistent with the best practice.

32. Specific Gravity.

For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken at 8.89 grams per cubic centimeter at a temperature of 20 deg. Cent.

33. Permissible Variations from Dimensions.

The variations from the nominal diameter shall not exceed the following:

(a) *Untinned Wire*—For wire 0.010 inches or over in diameter, one per cent. over or under.

For wires less than 0.010 inches in diameter, 0.1 mil (0.0001 in.) over or under.

(b) *Tinned Wire*—For wire 0.010 inches or over in diameter, three per cent. over and one per cent. under.

For wire less than 0.010 inches in diameter 0.3 mils over and 0.1 mil under.

Cables otherwise meeting the specifications but having a cross-sectional area of not over one per cent. less than that specified may be accepted by the Railroad upon a satisfactory adjustment in price.

34. Gaging.

The wire on each coil, reel or spool shall be gaged wherever desired by the Inspector, but in the case of coils at not less than three places, one near each end and one approximately at the middle. In the case of spools, not less than twelve feet of wire or cable shall be reeled off, and the wire shall be gaged in six places between the second and twelfth foot from the end. The coils or spools will be rejected if the average of the measurements obtained is not within the limits stated in Section 33.

35. Elongation.

The elongation of the wire shall be not less than specified in Table IV. Tests shall be made upon fair samples, and the elongation shall be determined as the permanent increases in lengths, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally ten inches apart. The fracture shall be between the bench marks and not closer than one inch to either mark. If fracture occurs outside the bench marks, or closer than one inch to either mark, the test shall be repeated. If upon testing a sample from any coil, reel or spool of wire, the results are found to be below the specified elongation, tests upon two additional samples shall be made, and if the average of the three results is below the specified elongation, the wire may be rejected. In the case of cables, tests shall be made on the individual wires.

36. Conductivity.

The electric conductivity shall be determined as described in Section 47 and shall be not less than the per cent. of the Annealed Copper Standard specified in Tables V and VI.

37. Tinning.

If the wire is to be insulated with rubber compound, it shall be covered with a heavy uniform coating of tin unless otherwise specified on the order.

Tinned wire shall be free from projections and shall successfully pass the following test:

Samples of wire which have not been insulated shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.09 corrected to 60 deg. Fahr. for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.14 for 30 seconds and again washed. This operation shall be repeated three times and upon the completion of the fourth cycle, the sample shall show no sign of blackening. The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five seconds.

38. Joints.

Joints will be permitted if properly brazed.

39. Packing and Shipping.

Table III gives the maximum and minimum weights of bare wire of stated sizes which may be shipped in any one package, whether coil, reel or spool; in the case of wire larger than 0.010 in. in diameter, the maximum and minimum package weights are net, and in the case of wire 0.010 in. and less in diameter, the maximum package weights are gross, and the minimum package weights are net. The table also states the limits of the dimensions of reels and spools on which wire may be shipped. The length and diameter stated for reels and spools are to be measured over all and are maximum sizes; reels or spools smaller than these may be used, provided the minimum weights called for are carried by the reel or spool.

40. End Defects.

To insure the removal of defects from the wire, the Manufacturer shall cut off at least 25 feet of wire, or as much more as may be necessary from each end of every coil, reel or spool.

TABLE III—PACKAGES OF BARE SOFT OR ANNEALED COPPER WIRE

Diameters, In.	Package Weights Pounds		Dimension of Reels and Spools, In.		
	Max.	Min.	Max. Dia.	Max. Length	Diameter of Hole for Rod
0.460 to 0.360	520	290	32	21	1½ to 2½
0.359 " 0.258	430	290	32	21	1½ " 2½
0.257 " 0.129	290	140	24	12	1½ " 2½
0.128 " 0.102	230	95	24	12	⅝ " 1½
0.101 " 0.083	230	75	24	12	⅝ " 1½
0.082 " 0.081	200	75	24	12	⅝ " 1½
0.080 " 0.064	200	50	24	12	⅝ " 1½
0.063 " 0.051	120	50	24	10	⅝ " 1½
0.050 " 0.041	100	50	24	10	⅝ " 1½
0.040 " 0.032	50	20	24	8	⅝ " 1½
0.031 " 0.020	25	15	10	6½	⅝ " ⅞
0.019 " 0.011	10	5	5½	4	⅜ " 11/16
0.010 " 0.008	5	2½	4	4	⅜ " 11/16
0.007 " 0.0056	2½	1	2½	4	⅜ " 11/16
0.005	1½	⅝	2½	4	⅜ " 11/16
0.004	1½	⅜	2½	4	⅜ " 11/16
0.003	1	¼	2½	4	⅜ " 11/16

TABLE IV—ELONGATION OF SOFT (ANNEALED) COPPER WIRE

Diameter, In.	Minimum Per Cent of Elongation in 10 In.		Diameter, In.	Minimum Per Cent of Elongation in 10 In.	
	Tinned	Untinned		Tinned	Untinned
0.460 to 0.290	30	35	0.200 to 0.151	27.5	
0.289 " 0.103	25	30	0.150 " 0.101	25.0	Note: Use these percentages for samples of tinned wires taken from stranded cables.
0.102 " 0.021	20	25	0.100 " 0.061	22.5	
0.020 " 0.012	15	20	0.060 " 0.031	20.0	
0.011 " 0.003	10	20	0.030 " 0.003	17.5	

For intermediate sizes the requirements shall be those of the next smaller size.

TABLE V—CONDUCTIVITY OF SOFT OR ANNEALED UNTINNED COPPER WIRE

A. W. G. No.	Conductivity, per cent	A. W. G. No.	Conductivity, per cent
0000 to 8	98.5	20 to 30	97.5
8 to 20	98.0	Smaller than No. 30	97.0

For intermediate sizes the requirements shall be those of the next smaller size.

Table VI—Conductivity of Soft or Annealed Tinned Copper Wire

A. W. G. No.	Conductivity per cent	A. W. G. No.	Conductivity per cent
9 and larger	98.0	20	95.8
10	97.8	21	95.6
11	97.6	22	95.4
12	97.4	23	95.2
13	97.2	24	95.0
14	97.0	25	94.8
15	96.8	26	94.6
16	96.6	27	94.4
17	96.4	28	94.2
18	96.2	29	94.0
19	96.0	30	93.8

For intermediate sizes the requirements shall be those of the next smaller size.

HARD DRAWN COPPER WIRE AND CABLE.

41. General.

The intention of these specifications is to describe hard drawn copper wire of the best commercial quality.

42. Shape.

The wire shall be of circular cross-section, unless otherwise specified.

43. Surface Imperfections.

The wire shall be free from all surface imperfections not consistent with the best practice.

43-A. Specific Gravity.

For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken at 8.89 grams per cubic centimeter at a temperature of 20 deg. Cent.

44. Core.

Standard conductors shall be made of hard drawn wire laid concentrically about a core of material specified in the specifications accompanying the order. Unless otherwise specified the core of seven-wire cables shall be of semi-hard drawn copper.

45. Permissible Variation from Dimensions.

The circumference of any cross-section of the wire shall be a true circle.

The variations from the nominal diameter shall not exceed the following:

(a) *Untinned Wire*—For wire 0.010 in. in diameter and larger, one per cent. over and under.

For wire less than 0.010 in. in diameter, 0.1 mil (0.0001 in.) over or under.

(b) *Tinned Wire*—For wire 0.02 in. in diameter, and larger, two per cent. over or one per cent. under.

For wire less than 0.02 in. in diameter, 0.1 mil under.

Where the area of cross-section of cables is specified, the cables shall be of not less than the area specified.

46. Brazes.

Brazes made before drawing, in accordance with the best practice, will be permitted in wire entering into cables, but no two brazes in a strand may be closer together than 50 ft. in wire larger than No. 5 A.w.g. or closer than 100 ft. on smaller wires. Brazes will be allowed in single wire conductors only where the length specified exceeds that which can be drawn from an ingot. No joints shall be made in wire after drawing.

47. Conductivity.

Electrical conductivity shall be determined upon fair samples by resistance measurement with a Kelvin bridge or other instrument approved by the Railroad. The use of the Hoops bridge is approved.

Samples shall be cut from not less than ten per cent. of the coils in each lot of wire, the number of samples being never less than two. The conductivity shall be not less than the following per cent. of the Annealed Copper Standard:

For diameters 0.460 to 0.325 in., 97 per cent.
For diameters 0.324 to 0.040 in., 96 per cent.

If the average conductivity is less than specified above, the entire lot may be rejected.

48. Extensometer Test.

If required by the Engineer, fair samples shall be cut from not less than ten per cent. of the coils in each lot of wire, the number of samples being never less than two, and extensometer tests shall be made upon them, and the results on each sample plotted as a curve. The point at which the ratio of the elongation to the stress begins to increase shall be at a stress not less than 55 per cent. of the ultimate strength of the sample.

If more than 20 per cent. of the samples fail to pass this test, the entire lot may be rejected.

49. Tensile Strength and Elongation.

The tensile strength and elongation of the wire shall be not less than specified in Table VII. Tensile tests shall be made upon fair samples, and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally ten or sixty inches apart, as specified in Table VII. The fracture shall be between the bench marks and not closer than one inch to either mark. If the fracture occurs outside the bench marks or closer than one inch to either mark, the tests shall be repeated. Samples shall be cut from not less than ten per cent. of the coils in each lot of wire, the number of samples being never less than two. If more than ten per cent. of the samples fail to pass this test, the entire lot may be rejected.

Table VII—Tensile Strength and Elongation of Hard Drawn Copper Wire

A. W. G. No.	Diameter, Inches	Area, Cir. Mils.	Tensile Strength, Lb. Per Sq. In.	Elongation, Per Cent in 10 In.
0000	0.4600	211 600	49 000	3.75
000	0.4096	168 100	51 000	3.25
00	0.3648	133 225	52 800	2.80
0	0.3249	105 625	54 500	2.40
1	0.2893	83 520	56 100	2.17
2	0.2576	66 565	57 600	1.98
3	0.2294	52 440	59 000	1.79
4	0.2043	41 615	60 100	In 60 in. 1.24
5	0.1819	33 125	61 200	1.18
6	0.1620	27 225	62 000	1.14
7	0.1443	26 245	62 100	1.14
8	0.1285	20 735	63 000	1.09
9	0.1144	17 956	63 400	1.07
10	0.1019	16 385	63 700	1.06
11	0.09074	12 995	64 300	1.02
12	0.08081	10 815	64 800	1.00
13	0.07196	10 404	64 900	1.00
14	0.06408	8 464	65 400	0.97
15	0.05707	8 281	65 400	0.97
16	0.05082	6 561	65 700	0.95
17	0.04526	6 400	65 700	0.94
18	0.04030	5 184	65 900	0.92
19	0.03589	4 225	66 200	0.91
20	0.03196	4 096	66 200	0.90
21	0.02846	3.249	66 400	0.89
22	0.02535	2 601	66 600	0.87
23	0.02257	2 025	66 800	0.86
24	0.02010	1 600	67 000	0.85

For intermediate sizes, the requirements shall be those of the next larger size. A reduction of 10 per cent. in the tensile strength of wires taken from stranded cables will be allowed when the wires are tinned and 3 per cent. when untinned.

50. Tensile Strength of Cable.

The tensile strength of cables shall be not less than 90 per cent. of the total tensile strength of the component wires, exclusive of the core if the latter is not made of hard drawn copper.

51. End Defects.

To insure the removal of defects from the wire, the Manufacturer shall cut off at least 25 ft. of wire, or as much more as may be necessary from each end of every coil, reel or spool.

CLASS "A" RUBBER INSULATION WITH MINERAL BASE.

52. Constituents.

Class "A" rubber insulation shall consist of a properly vulcanized compound consisting of not less than 30 per cent. fine Para or smoked first latex plantation Hevea rubber with mineral fillers. It shall contain only the following ingredients:

Rubber,
Sulphur,
Inorganic mineral matter,
Refined solid paraffine or ceresine.

It shall not contain either red lead or carbon.

53. Results of Analysis.

The vulcanized compound shall conform to the following requirements, when tested by the procedure of the Joint Rubber Insulation Committee current at the date of order.

(a) Results to be expressed as percentages by weight of the whole sample:

	Maximum	*Minimum*
Rubber	33	30
Waxy hydrocarbons	4	0
Free sulphur	0.7	0

(b) The requirements for intermediate percentages shall be in proportion to the percentage of the rubber found:

Limits allowed for 30% Rubber Compound	*Maximum*	*Minimum*
Saponifiable acetone extract	1.35	0.55
Unsaponifiable resins	0.45	0
Chloroform extract	0.90	0
Alcoholic potash extract	0.55	0
Total sulphur	2.10	0
Specific gravity	0	1.75

Limits allowed for 33% Rubber Compound	*Maximum*	*Minimum*
Saponifiable acetone extract	1.50	0.60
Unsaponifiable resins	0.50	0
Chloroform extract	1.00	0
Alcoholic potash extract	0.60	0
Total sulphur	2.10	0
Specific gravity	0	1.67

(c) The acetone solution shall not fluoresce.

(d) The acetone extract (60 cu.cm.) shall be not darker than a light straw color.

(e) Hydrocarbons shall be solid, waxy and not darker than a light brown color.

(f) Chloroform extract (60 cu.cm.) shall be not darker than a straw color.

Failure to meet any requirement of these specifications will be considered sufficient cause for rejection.

(g) Contamination of the compound by the use of impregnated tapes will not excuse the Manufacturer from conforming to these specifications. The use of fine Para or first quality plantation rubber, without compliance with the chemical limits, will not be sufficient for acceptance.

54. Check Analysis.

If the Manufacturer questions the accuracy of the analytical results upon which rejections are based, the Railroad will have an analysis made by another chemist, using the procedure of the Joint Rubber Insulation Committee. If the results of such analysis show the rubber compound to be in accordance with the specifications, the Railroad will bear the expense thereof; otherwise the Manufacturer shall bear the expense. (See Section 5.)

55. Concentric Application.

The compound shall be applied concentrically about the conductor and shall fit closely thereto. If necessary, in order to achieve this result on insulated conductors of greater diameter than 0.3 of an inch, a tape may be applied over the insulation before vulcanization. Such tape, if it does not comply with Section 73, will be additional to any which may be required in the accompanying wire specifications. Where the insulation is applied in more than one layer, adjacent layers shall cohere firmly.

56. Thickness of Insulation.

Unless otherwise specified the minimum thickness of insulation at any point shall be in accordance with Table VIII.

TABLE VIII—THICKNESS OF RUBBER INSULATION

30 Per Cent. Hevea Rubber Compound, Wall Thickness in 64th of an Inch

Size of Conductor, A. W. G. or Cir. Mils.	Working Pressure											
	a-c or d-c	3rd Rail Rys.		Volts—Alternating								
	600 or less	601 to 750	1500	2500	3500	5000	6000	7000	8000	9000	10000	11000
14–8	3	4	6	8	10	12	14	16	18	20	22	24
7–2	4	5	7	9	10	12	14	16	18	20	22	24
0000	5	6	8	10	10	12	14	16	18	20	22	24
400,000	6	7	9	10	11	12	14	16	18	20	22	24
500,000	6	8	9	10	11	12	14	16	18	20	22	24
2,000,000	7	9	10	10	12	12	14	16	18	20	22	24
2,000,000	8	10	10	10	12	14	16	18	18	20	22	24

For intermediate sizes the insulation thickness specified for the next larger size shall be used

57. Elasticity.

(a) Samples from wires of No. 8 A.w.g. or less shall be obtained by the removal of the copper wire by the elongation of the wire, or if tinned by the mercury process at the option of the Inspector.

From larger wires a sample of approximately 1/32 sq. in. rectangular cross-section shall be cut from the insulated conductor, using a sharp knife. The sample shall be bent in every direction to magnify and reveal any surface cracks or imperfections which may exist.

(b) Two thin bench marks shall be marked on the test sample two inches apart and at right angles to the direction of pull.

The sample shall then be clamped in an approved testing machine and stretched at the rate of twenty inches per minute until the marks are six inches apart and held for one minute and then immediately released. One minute after release the marks shall not be farther apart than specified in Table IX.

TABLE IX—ELONGATION AND PERMANENT SET OF GRADE A RUBBER COMPOUND

Sections	Lengthening, Stretching and Release	Length at Instant of Fracture
No. 8 and smaller, full section.........................	2⅜ inch	10 inch
Larger than No. 8, 1-32 square inch..................	2⅜ inch	9 inch

58. Tensile Strength.

A sample prepared as described in Section 57 (a) shall be taken from every 5,000 ft. or less and stretched in an approved testing machine at the rate of 20 in. per minute until it breaks.

The tensile strength shall be not less than 1,000 lb. per square inch. At the instant of fracture the distance between bench marks shall be not less than specified in Table IX.

59. Electrical Tests.

(a) Each and every length of wire or cable shall conform to the requirements of Sections 70 and 71. Electrical tests shall be made upon rubber insulated wire or cable after at least eighteen hours immersion in water, while still immersed and before the application of any covering other than the tape used in vulcanization. In the case of multiplex cables, the high potential test shall be made and the insulation resistance shall be measured before assembling the conductors. An additional electrical test shall be made on lead covered or armored cable and shall consist of a high potential test to be made upon the cable after assembling and leading or armoring, and, if lead covered, without immersion in water. In the case of multiplex cables, this test shall be made successively between each conductor and the other conductors and sheath in multiple. The potential test shall be repeated on lead covered armored cables after armoring. (See Section 2.)

(b) The insulation resistance (megohms) at a given temperature shall be reduced to that at 15.5 deg. Cent. (60 deg. Fahr.) by multiplying by the coefficient in Table XIV corresponding to that temperature. Tests shall be made at temperatures within the range of Table XV.

VARNISHED CLOTH INSULATION.

60. Description.

The insulation shall consist of a closely woven cotton cloth and viscous filler. Each surface of the cloth shall have a smooth continuous film of varnish and shall be free from wrinkles, blisters, and other imperfections. It shall be thoroughly impregnated with insulating compound, be pliable and have no tendency to crack when doubled on itself. A separator, which shall conform to Section 72, will be permitted.

61. Thickness of Insulation.

Unless otherwise specified the thickness of insulation shall be in accordance with Table X.

TABLE X—THICKNESS OF VARNISHED CLOTH INSULATION IN 64TH-IN.

Size of Conductor	D-C 0 to 500V	D-C 501 to 1500V	Single or Two-Phase up to 2500V	Belted Cables			
				3-Phase Grounded Neutral Volts between Phases			
				6000 to 7000		11000 to 12000	
				Each Cond.	Belt	Each Cond.	Belt
Cir. Mils.							
2,000,000	9	10	....	....	....	....	....
1,750,000	9	9	....	....	....	....	....
1,500,000	8	9	....	....	....	....	....
1,250,000	8	8	....	....	....	....	....
1,000,000	7	8	10	....	....	....	....
500,000	6	7	9	....	....	12	8
250,000	6	7	9	8	6	12	8
A. W. G.							
0000	5	6	9	8	6	12	8
1	5	6	9	8	6	12	8
8	4	6	9	8	6	12	8

For intermediate sizes the requirements shall be those of the next larger size.

On single conductor cables in three-phase system the thickness of insulation on each conductor shall be the sum of those specified for each conductor and belt. For all sizes above 500,000 cir.mil. having a voltage between phases of 11,000 to 12,000 volts, the thickness shall be 28/64 in. Double conductor cables in three-phase systems shall have the same insulation on each conductor and belt as the three conductor cables.

62. Filler.

The filler shall be a viscous moisture-repelling insulating compound having a dielectric constant approximately the same as that of the varnished cloth insulation and of such a nature as to have no deleterious effect upon the varnish. It shall prevent the tapes from unwrapping when cut, but allow the layers to slide upon each other when cable is bent.

63. Assembly.

The insulating cloth shall be applied in the form of tape wound on helically and reversed at least every two layers. The tapes shall be of such widths that they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers shall be staggered. The filler shall be applied between layers as to exclude all air and moisture, the whole forming a hard semi-flexible wall of insulation.

64. Tape.

A layer of cloth tape, which shall conform to the requirements of Section 73, shall be applied over the cloth insulation. In the case of multiple conductor cables, a tape shall be applied over each conductor and one over the belt.

65. Electrical Tests.

Each and every length of wire or cable shall conform to the requirements of Sections 70 and 71. Electrical tests shall be made upon varnished cloth insulated wire or cable after at least one hour immersion in water, and while still immersed. If the wire or cable is to be covered with dry or flameproof braid, tests shall be made before the braid is applied; if it is to be covered with weatherproof braid, the tests shall be made on the finished product. Lead covered conductors shall be tested against the sheath with sheath grounded. Multiple-conductor cables and covered cables shall be tested between each conductor and the other conductors and sheath or ground in multiple. The potential test shall be repeated on armored cables after armoring.

Impregnated Paper Insulation.

66. Description.

The insulation shall consist of Manila paper applied helically and evenly to the conductor, and then thoroughly impregnated with an insulating compound. The cable shall be pliable and show no tendency to harden injuriously at 0 deg. Cent. (32 deg. Fahr.). The paper shall contain no free mineral acids or free alkalis. The compound shall be so applied as to exclude all air and moisture, and shall contain no free mineral acid, alkali or other substances which have a deleterious effect upon the paper, copper or compound.

67. Thickness of Insulation.

Unless otherwise specified, the thickness of insulation shall be in accordance with Table XI.

68. Tensile Strength.

Tensile strength tests shall be made upon paper taken from any finished cable, both from conductor and belt, if any. Test pieces ten feet in length shall be selected, looped and tension applied at the loop through a mandrel, the diameter of which is equal to the width of the paper.

A tension of 5,000 lb. per square inch shall be applied for 5 minutes, and then 6,500 lb. per square inch for 1 minute. If more than one out of six samples selected from each lot by the Inspector fail to meet the tests, the entire lot may be rejected.

69. Electrical Tests.

Each and every length of finished wire or cable shall conform to the requirements of Sections 70 and 71. No immersion is required before testing. The potential test shall be made between conductor and sheath with the sheath grounded. Multiple conductor cables shall be tested between each conductor, and the other conductors and sheath or ground in multiple. The potential test shall be repeated on armored cables after armoring.

TABLE XI—THICKNESS OF IMPREGNATED PAPER INSULATION—64TH INCH

Size of Conductor	D-C. up to 500 V.	D-C. 501 to 1500 V.	Single or two phase up to 2500 V.	Belted Cables. 3-Phase Grounded Neutral Volts between Phases.			
				6000—7000		11000—12000	
				Each Cond.	Belt	Each Cond.	Belt
Cir. mil.							
2 000 000	9	10	....	....	....	....	....
1 750 000	9	10	....	....	....	....	....
1 500 000	8	9	....	....	....	....	....
1 250 000	8	9	....	....	....	....	....
1 000 000	7	9	12	....	....	....	....
750 000	7	9	12	....	....	....	....
500 000	6	8	10	....	....	....	....
250 000	6	8	10	9	6	14	9
A. W. G.							
0000	5	7	10	9	6	14	9
2	4	7	10	9	6	14	9
5	4	7	10	9	6	....	....
6	4	7	10	9	6	....	....
7	4	7	10	....	....	....	....
8	4	7	10	....	....	....	....
9	4	5	....	....	....	....	....
10	4	5	....	....	....	....	....

For intermediate sizes, the requirements shall be those of the next larger size.

On single conductor cables in three-phase systems the thickness of insulation on each conductor shall be the sum of those specified for each conductor and belt. For all sizes above 500,000 cir.mil. having a voltage between phases 11,000 to 12,000 volts, the thickness shall be 28/64 in. Double conductor cables in three-phase systems shall have the same insulation on each conductor and belt as the three conductor cables.

ELECTRICAL TESTS OF INSULATION AT FACTORY.

70. High Potential Test.

The high potential test voltage specified in Table XII and Table XIII shall be applied for five minutes; shall have a frequency not exceeding 100 cycles per second and shall approximate as closely as possible to a sine-wave. The initially applied voltage shall not be greater than the working voltage, and the rate of increase shall be approximately uniform and not over 100 per cent. in ten seconds. The source of energy shall be of ample capacity.

71. Insulation Resistance.

The insulation resistance shall be measured after the high potential test and after a one minute electrification with a battery having an e.m.f. of not less than 100 and not more than 500 volts. The results corrected to the standard temperature of 15.5 deg. Cent. (60 deg. Fahr.) shall conform with the requirements of Table XIV. In the case of multiplex cables, the values in the tables shall apply to each conductor.

SEPARATOR.

72. Separator.

The separator may consist of a wind or braid of soft cotton yarn, or in the case of conductors of No. 6 A.w.g. and larger, a muslin tape. With untinned conductors, the separator shall completely cover the conductors; with tinned conductors the separator shall allow the insulation sufficient contact with the conductor to prevent the conductor sliding in the insulation.

RUBBER FILLED CLOTH TAPE.

73. Tape.

The tape shall consist of cotton cloth not lighter than one-quarter lb. per square yard, with not less than 56 by 60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied helically overlapping not less than specified in Table XVI, which also gives the maximum width of tape allowed.

TABLE XII—TEST POTENTIALS FOR RUBBER INSULATION

Potentials in Kilovolts—Five Minute Test.

Size of Conductors.	THICKNESS OF INSULATION, 64TH INCH.									
	2	3	4	5	6	7	8	9	10	12
Cir. mils.										
2 000 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 750 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 500 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 250 000	....	....	....	....	....	....	4.0	5.0	6.0	9.0
1 000 000	....	....	....	....	....	4.0	5.0	6.0	7.0	10.0
750 000	....	....	....	....	....	4.0	5.0	6.0	7.0	10.0
500 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
350 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
250 000	....	....	....	3.0	4.0	5.0	6.0	7.0	8.0	11.0
0 000	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
000	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
0	....	....	....	3.5	4.5	5.5	6.5	7.5	8.5	11.5
1	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
2	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
4	....	....	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
6	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
8	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
10	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
12	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
14	....	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	13.0
16	1.0	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5
18	1.0	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	12.5

For greater thicknesses add 1500 volts for each $\frac{1}{64}$ inch.

TABLE XIII—TEST POTENTIALS FOR VARNISHED CLOTH AND IMPREGNATED PAPER.

Potentials in Kilovolts—Five Minute Test.

For Varnished Cloth use 100 per cent. of the following potentials.
For Impregnated Paper use 75 per cent. of the following potentials.

Size of Conductors	THICKNESS OF INSULATION, 64TH INCH.							
	3	4	5	6	7	8	9	10
Cir. mils.								
2 000 000	....	....	....	....	....	5.0	8.0	10.5
1 750 000	....	....	....	....	....	6.5	8.5	11.5
1 500 000	....	....	....	....	....	7.0	9.5	12.0
1 250 000	....	....	....	....	....	7.5	10.0	12.5
1 000 000	....	....	....	....	5.5	8.0	10.5	13.0
750 000	....	....	....	....	6.5	9.0	11.5	14.0
500 000	....	....	2.5	5.0	7.5	10.0	12.5	14.5
350 000	....	....	3.5	6.0	8.5	10.5	13.0	15.0
250 000	....	....	4.0	6.5	9.0	11.0	13.5	15.5
A. W. G.								
0000	....	....	4.5	7.0	9.0	11.5	13.5	15.5
000	....	....	5.0	7.5	9.5	11.5	13.5	15.5
0	....	....	5.5	8.0	10.0	12.0	13.5	15.5
1	....	4.0	6.0	8.0	10.0	12.0	13.5	15.5
2	....	4.0	6.0	8.0	10.0	12.0	13.5	15.0
4	....	4.5	6.5	8.5	10.0	11.5	13.0	14.5
6	3.0	5.0	6.5	8.5	10.0	11.5	12.5	14.0
8	3.0	5.0	7.0	8.0	9.5	11.0	11.5	13.0
10	3.0	5.0	6.5	8.0	8.5	10.0	10.5	12.0

THICKNESS OF INSULATION

Size of Conductors.	THICKNESS OF INSULATION, 64TH INCH.								
	12	14	16	18	20	22	24	26	28
Cir. Mil.									
250 000	17	20	23	25	28	31	33	36	38
A. W. G.									
0000-1	16	19	22	24	27	30	32	34	36
2-4	15	17	20	23	25	28	30	32	34
5 & 6	15	17	19	21	23	26	28	30	31

For intermediate sizes the requirements shall be those of the next larger size. Where the insulation thickness is less than the minimum for which test voltages are given, no potential will be required.

TABLE XIV—MEGOHM-MILES AT 15.5 DEG. CENT. (60 DEG. FAHR.)

One Minute Electrification.

Rubber, minimum shall be 100 per cent. of following.
Varnished Cloth, minimum shall be 15 per cent. of following.
Impregnated Paper, minimum shall be 12½ per cent. of following.

Size of Conductors				Thickness of Insulation, 64th Inch										
	2	3	4	5	6	7	8	9	10	12	14	16	18	20
Cir. Mls.														
2,000,000	.....	.....	.....	.....	.....	225	200	250	275	325	350	.....	.....	.....
1,750,000	.....	.....	.....	.....	200	225	275	300	375	425	425	.....	.....	.....
1,500,000	.....	.....	.....	.....	225	250	300	325	325	400	475	.....	.....	.....
1,250,000	.....	.....	.....	200	250	275	325	350	375	425	500	575	.....	.....
1,000,000	.....	.....	.....	225	275	300	350	375	400	475	575	625	.....	.....
750,000	.....	.....	.....	250	300	325	400	450	475	525	625	750	800	.....
500,000	.....	.....	250	300	375	400	475	525	575	675	750	800	950	.....
350,000	.....	.....	300	350	425	475	525	600	675	775	850	950	1150	.....
250,000	.....	.....	350	400	475	575	625	675	725	875	1000	1050	1200	1250
A. W. G.														
0000	...		375	450	550	600	650	700	800	950	1050	1150	1250	1350
000	.....	.....	400	500	600	650	750	800	850	1000	1150	1250	1350	1450
00	.....	.....	450	550	650	750	850	900	950	1050	1250	1350	1450	1600
0	.....	.....	500	600	700	800	950	1000	1050	1200	1350	1450	1600	1650
1	.....	500	600	650	750	850	1000	1050	1150	1350	1450	1600	1750	1800
2	.....	550	650	750	850	950	1050	1150	1250	1450	1600	1750	1850	2000
4	.....	650	750	850	1000	1150	1250	1400	1450	1650	1850	2000	2150	2250
6	.....	800	850	1050	1200	1350	1450	1600	1750	1950	2050	2250	2400	2550
8	.....	850	1050	1250	1450	1650	1750	2000	2050	2200	2400	2600	2750	2850
10	.....	1150	1350	1600	1800	2000	2150	2300	2400	2650	2850	3050	3200	3400
12	.....	1350	1600	1850	2050	2250	2400	2600	2750	3000	3200	3400	3600	3800
14	.....	1550	1850	2150	2350	2550	2650	2900	3050	3500	3550	3750	3850	4050
16	1400	1800	2150	2400	2650	2850	3050	3250	3400	3650	3850	4150	4250	4450
18	1600	2050	2450	2800	3000	3200	3400	3600	3750	4050	4250	4450	4750	4850

For intermediate sizes, the requirements shall be those of the next larger size. For cables having insulation over 20/64 in. in thickness, or copper cross-section greater than two million circular mils, the table may be extended by means of the formula: $\text{Megohms} = 4000 \log_{10} \frac{D}{d}$ where D is outside diameter of insulation and d is diameter of equivalent solid wire.

TABLE XV—TEMPERATURE COEFFICIENTS FOR RESISTANCE OF RUBBER COMPOUND.

The insulation resistance at a given temperature shall be reduced to that at 15.5 deg. Cent. (60 deg. Fahr.) by multiplying by the coefficient corresponding to that temperature.

(Centigrade Degrees.)

Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient	Temperature deg. Cent.	Coefficient
7	.65	16	1.02	12	.85	21	1.30
8	.69	17	1.07	13	.89	22	1.37
9	.73	18	1.12	14	.93	23	1.43
10	.77	19	1.17	15	.98	24	1.49
11	.81	20	1.23	15.5	1.00	25	1.56

(Fahrenheit Degrees.)

Temperature deg. Fahr.	Coefficient	Temperature deg. Fahr.	Coefficient	Temperature deg. Fahr.	Coefficient	Temperature deg. Fahr.	Coefficient
46	.69	61	1.03	55	.88	70	1.30
47	.71	62	1.05	56	.90	71	1.33
48	.73	63	1.08	57	.92	72	1.37
49	.75	64	1.11	58	.94	73	1.40
50	.77	65	1.14	59	.97	74	1.44
51	.79	66	1.17	60	1.00	75	1.48
52	.81	67	1.20				
53	.83	68	1.23				
54	.85	69	1.26				

TABLE XVI—WIDTH AND OVERLAP OF RUBBER FILLED CLOTH TAPE.

Diameter over Insulation, Inches	Maximum Width of Tape, Inches	Maximum Overlap, Inches	Diameter over Insulation, Inches	Maximum Width of Tape, Inches	Maximum Overlap, Inches
2.00	5	½	0.62	2	⅜
1.75	4½	½	0.50	1¾	⅜
1.50	4	½	0.38	1½	¼
1.25	3½	½	0.31	1¼	¼
1.15	3¼	½	0.25	1	¼
1.00	3	½	0.19	⅞	⅛
0.88	2¾	⅜	0.16	¾	⅛
0.75	2⅜	⅜			

For intermediate sizes the requirements shall be those of the next smaller size.

BRAID.

74. Weatherproof Braid.

Braid, unless otherwise specified, shall be of closely woven cotton thread, at least two-ply, thoroughly impregnated with an insulating weatherproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. Cent. (194 deg. Fahr.). The thickness of each braid shall be not less than given in the following table:

Table XVII—Thickness of Cotton Braid.

Diameter Under the Braid or Jute, if any, Inches	Thickness of Braid, Inches	Diameter Under the Braid or Jute, if any, Inches	Thickness of Braid, Inches
1.000 and over	0.053	0.290	0.028
0.530	0.038	0.160	0.018

For intermediate sizes, the requirements shall be those of the next smaller size.

For twin cable use mean diameter.

(This table does not apply to fancy or special braids for fixtures, weatherproof wire, or cable, etc.)

75. Tests.

A six-inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20 deg. Cent. (68 deg. Fahr.) for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than nine per cent. of the weight exclusive of copper and insulation before submersion. The compound shall not drip at a temperature of 50 deg. Cent. (122 deg. Fahr.).

76. Circular Loom Braid.

Circular loom braids shall be of cotton and unless otherwise specified, shall be each one-sixteenth inch in thickness. The braid shall be impregnated with a black insulating compound which shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. (194 deg. Fahr.). The compound shall not drip at a temperature of 50 deg. Cent. (122 deg. Fahr.).

The braid shall be coated with loose mica.

Dry Paper Tape.

77. Paper Tape.

Dry paper tape shall be of high grade Manila paper not less than five mils thick and shall be applied helically lapping at least one-third its width.

Miscellaneous Braids.

78. Glazed Cotton Braid.

Glazed cotton braid shall be of smooth glossy hard finished black cotton and no compound shall be applied to the finished braid. Glazed braids for telephone wires shall be so applied as not to slip.

79. Hemp Braid.

Hemp braid shall be of six-lea hemp thoroughly impregnated with an insulating weatherproof compound. The compound shall neither be injuriously affected by nor have injurious effect upon the braid at a temperature of 95 deg. Cent. (203 deg. Fahr.).

80. Colored Braid.

Colored braid shall consist of cotton impregnated with fast colors and shall be glazed except where they have an outer cover as in multiple conductor cables, when they shall be unglazed. The yarns shall be approved by the Inspector before they are applied.

80-A. Flameproof Braid.

The braid shall be of closely woven cotton thread at least two-ply, thoroughly impregnated with a compound which will render it non-inflammable.

Lead Sheath.

81. Composition.

The lead sheaths of cable, except telephone cables, shall consist of commercially pure lead. The sheaths of telephone cables shall be composed of an alloy of lead and antimony; the amount of antimony being approximately one per cent.

82. Thickness.

Unless otherwise specified the sheath shall have an average thickness not less than that indicated in Table XVIII and the minimum thickness shall in no place be less than 90 per cent. of the required average thickness.

Table XVIII—Thickness of Sheath.

Diam. of Core, Inches	Thickness of Sheath in 64th Inch		Diam. of Core, Inches	Thickness of Sheath in 64th Inch	
	For Paper Insulation	For Rubber or Varnished Cloth Insulation		For Paper Insulation	For Rubber or Varnished Cloth Insulation
2.70 and over......	10	9	0.70..............	7	6
2.00...............	9	8	0.30...............	6	5
1.25...............	8	7	Less than 0.30.....	5	4

For intermediate sizes the requirements shall be those of the next smaller size.

For twin cable, use mean diameter.

Galvanized Steel Wire Armor.

83. General.

The purpose of these specifications is to describe the armoring of insulated wire and cable with galvanized steel wire.

84. Preparation for Armor.

(*a*) *Cloth Taped or Braided Cables*—The cable shall be run through a hot asphalt compound, served with a helical layer of jute yarn, run through hot asphalt compound, then served with a second layer of jute yarn, run through hot asphalt compound and then laid with galvanized wire.

(*b*) *Lead Sheathed Cables*—The leaded cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt again, and then laid with galvanized wire.

85. Thickness of Jute Bedding.

The jute bedding under the armor, measured in the finished cable, shall be not less than 3/32nds of an inch on taped or braided cables and not less than 2/32nds of an inch on lead sheathed cables.

86. Armor Wire.

The armor shall consist of galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Splices in the armor wire shall be smooth.

87. Application of Armor.

The armor shall be applied closely without appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

88. Covering Over Armor.

The armored cable shall be run through hot asphalt compound, served with a layer of the best three-ply 14 lb. hard twisted jute yarn spun on with a close short lay, run through hot asphalt compound, then served with a second layer of the best three-ply, 14 lb. jute yarn, run through hot asphalt compound, and finally run through some material to prevent sticking.

89. Direction of Lay.

Successive layers of jute, or jute and armor, shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the direction of lay of the armor shall be opposite to that of the outside layer of conductors.

90. Size of Wire.

Unless otherwise specified, the armor wire shall be of the size specified in Table XIX. The same number of the Birmingham wire gage will be acceptable.

TABLE XIX—SIZE OF STEEL ARMOR WIRE.

Diameter of Cable under Jute Bedding, Inches	Minimum Size of Wire, Steel Wire Gage	Diam. of Wire, In.	Diameter of Cable under Jute Bedding, Inches	Minimum Size of Wire Steel Wire Gage	Diam. of Wire, In.
1.30 and over......	4	0.225	0.63...............	10	0.135
1.25...............	6	0.192	0.44...............	12	0.105
0.88...............	8	0.162	Less than 0.44.....	14	0.080

For intermediate diameters, the requirements shall be those of the next smaller diameter.

91. Samples for Test.

Samples for each of the following tests shall be taken at random from ten per cent. of the coils, the number of samples being never less than two. If more than 20 per cent. of the samples fail to pass the tests, the entire lot will be rejected.

92. Tensile Strength and Elongation.

The wire shall have a tensile strength of not less than 50,000 pounds per square inch and an elongation of not less than ten per cent. in eight inches. The instructions for making tests, given in Section 49, shall be followed.

93. Galvanizing.

The galvanizing shall conform in every respect to the requirements of Sections 97 to 102.

94. Flexibility.

The armor wire shall be capable of being bent around a spindle ten times the diameter of the wire and straightened without developing cracks in the galvanizing, visible to the naked eye.

STEEL TAPE ARMOR.

95. Application of Armor.

The cable shall be run through hot asphalt compound, served with a layer of jute yarn spun on with a close short lay, run through hot asphalt compound, armored with a steel tape; armored with a second steel tape; run through hot asphalt compound, served with a layer of 3-ply, 14 lb. jute yarn with a close short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. Both steel tapes shall be laid in the same direction and the outer shall be centered over the spaces between turns of the inner. If the cable is rubber insulated, it shall be covered with tape, braid or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall not exceed one-tenth the width of the steel tape.

96. Armor Tape.

The galvanized steel tape and the jute, under the armor, after armoring, shall conform to the following table:

TABLE XX—SIZE OF STEEL TAPE AND JUTE FOR ARMORING CABLES.

Cable Diameter Before Armoring, Inches	Max. Width Steel Tape, Inches	Min. Thickness, each Tape, Inches	Minimum Jute Bedding, under Armor, Measured in Finished Cable, Inches
Over 2.00	2	0.05	2/32
2.00	1¾	0.04	2/32
1.70	1½	0.04	2/32
1.40	1¼	0.03	2/32
1.00	1	0.03	2/32
0.75	¾	0.02	2/32
0.45 or less	½	0.02	2/32

For intermediate diameters the requirements shall be those of the next larger diameter.

GALVANIZING.

97. General.

These specifications shall apply to galvanized iron or steel unless otherwise specified. Seven samples shall be taken from each lot for the purpose of the following test:

98. Coating.

The galvanizing shall consist of a continuous coating of commercially pure zinc of substantially uniform thickness, and so applied that it adheres firmly to the metal. The finished product shall be smooth.

99. Cleaning.

The samples shall be cleaned before testing, first with carbona, benzine or turpentine, and cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

100. Test.

The samples shall be immersed for one minute in a solution of copper sulphate of specific gravity 1.186 at 18.3 deg. Cent. (65 deg. Fahr.), rinsed in clean water and wiped dry. This operation shall be repeated until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with paraffin. The solution shall be saturated with copper sulphate to which an excess of chemically pure cupric oxide has been added, and shall be maintained at 15.5-20 deg. Cent. (60-68 deg. Fahr.) during the test.

101. Quantity of Solution.

Wire samples shall be tested in a glass jar of at least two inches inside diameter. The jar without the wire samples shall be filled with standard solution to a depth of at least four inches.

The solution shall not be used for more than one series of four immersions.

Not more than seven wires shall be simultaneously immersed, and not more than one sample of galvanized material other than wire shall be immersed in the specified quantity of solution.

The samples shall not be grouped or twisted together, but shall be well separated so as to permit the action of the solution to be uniform upon all immersed portions of the samples.

102. Results of Test.

In case of failure of only one sample in a group of seven samples immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven samples. If there is more than one failure in the original test or if either check test shows any failures, the lot may be rejected.

Cable Reels.

106. General.

Cable shall be delivered on reels which shall conform with the following requirements:

107. Form of Reel.

Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

108. Bushing.

If the shipping weight exceeds 300 lb. each disc or head of the reel shall be provided with a cast iron bushing or an iron plate, in the center of which shall be a hole 2½ in. in diameter. The bushing or plate shall be secured to the head by means of bolts through the head.

109. Size and Weight.

The reels shall be of suitable size and weight for the service in which they are used. Both the drum and the head diameters shall be selected with this in view.

110. Covering and Lagging.

Insulated cable shall be thoroughly covered with burlap before lagging is applied.

When used for insulated cable, the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

111. Marking.

A tag containing the following information shall be fastened to the coil inside the lagging with a duplicate securely fastened to the outside of the reel: (a) Name of Manufacturer; (b) size and number of conductors; (c) character of insulation; (d) gross pounds; (e) number of feet; (f) Railroad requisition and order number.

Each reel shall be given a number for identification.

112. Chocking.

Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

[7] RAILWAY SPECIFICATIONS FOR UNDERGROUND CONDUIT CONSTRUCTION FOR POWER CABLES.

GENERAL.

1. Scope.

These specifications describe the materials to be used and the processes to be employed in the construction of underground conduit lines for power cables for railroad purposes.

2. Materials, Drawings.

The conduit line and the materials used in its construction shall conform in every respect to the specifications. The accompanying drawings approved by the Engineer in charge shall form an essential part of these specifications.

3. Location of Conduit.

(a) Conduit lines shall be located so as to be subject to the least amount of disturbance and to interfere the least possible with prior installation.

(b) Preferably conduits shall be installed in a straight line between adjacent splicing chambers. If curves are unavoidable, they shall be of the greatest radius practicable. Curves of less than two hundred and fifty (250) ft. radius shall not be constructed unless approved by the Engineer in charge.

(c) Conduit lines paralleling a railroad shall be located as far as practicable from the tracks. Where located within six (6) ft., measured horizontally from the nearest rail, the elevation of the top of the conduit line shall be at least four (4) ft. below the base of rail. Where this is impracticable special protection shall be provided subject to the approval of the Engineer in charge. Where located six (6) ft. or more from a track rail the top of the conduit line shall have at least 2 ft. 6 in. (2′6″) of earth protection.

(d) Where conduit lines cross beneath the railroad tracks the top of the conduit protection shall be not less than four (4) ft. below the base of rail unless special protection is provided which shall be approved by the Engineer in charge.

DUCTS OR CONDUITS.

4. General.

The ducts or conduits shall be made of vitrified clay or impregnated wood fiber. They shall be straight and true and of uniform cross-section throughout and free from defects except as hereinafter permitted. The dimensions of the ducts or conduits shall conform to the dimensions shown on approved drawings within the limits hereinafter specified.

---

[7] Adopted, Vol. 22, 1921, pp. 140, 970.

VITRIFIED CLAY DUCTS.

5. Vitrified Clay Ducts.

(a) The shape of the duct shall be as shown on the approved drawing. The ducts shall be straight and true. The ends of each duct shall be perpendicular to its sides, and they shall be practically smooth and free from projection. The interior of the duct shall be beveled at each end.

(b) Ducts shall be made of finely divided clay free from stones or pebbles. The clay shall be thoroughly mixed, compacted, burned and vitrified. Ducts shall be glazed on all surfaces with a good salt glaze.

6. Defects.

(a) *Cracks*—Ducts shall not contain cracks which will appreciably weaken them. The presence of cracks shall be determined by tapping the ducts with a steel hammer or its approved equivalent, and any duct which fails to give a clear metallic ring under this test shall be rejected. Ducts having injurious air or fire cracks shall be rejected. Ducts having cracks in their surfaces which exceed one-sixteenth ($\frac{1}{16}$) of an inch in width or which extend injuriously into their surfaces shall be rejected.

(b) CHIPPED ENDS: Ducts having chipped ends may be accepted, providing the fracture does not extend further into the duct than the beveling.

(c) *Projections*—The interior surfaces of ducts shall be free from rough or sharp broken blisters or other projections and from smooth rounded unbroken blisters which project more than one-sixteenth ($\frac{1}{16}$) of an inch above the surface. Blisters or other projections on the outer surface of ducts shall not project more than three-sixteenths ($\frac{3}{16}$) of an inch above the surface. Smooth salt drip which does not project more than one-eighth ($\frac{1}{8}$) of an inch above the inner surface is not objectionable.

(d) *Recesses*—Recesses in the walls of ducts caused by broken blisters or other defects shall not decrease the thickness of the walls by more than three-sixteenths ($\frac{3}{16}$) of an inch. When on the inner surface, the edges of the recess shall be smooth.

7. Combing.

The outer surfaces of ducts shall be combed with two (2) sets of three (3) combings, each running lengthwise on the duct and placed adjacent to the corners.

8. Dimensions.

(a) *Length*—The unit length of standard clay ducts shall be eighteen (18) inches. Short lengths shall be approximately six (6), nine (9) and twelve (12) inches long.

(b) *Inside Dimensions*—The minimum inside dimensions of ducts shall be not less than that specified and the maximum not more than one-quarter ($\frac{1}{4}$) inch in excess thereof.

(c) *Wall Thickness*—The thickness of the walls of ducts shall be not more than three-quarters (¾) of an inch or less than nine-sixteenths ($\frac{9}{16}$) of an inch at the thinnest part of the section exclusive of the combing.

9. Tests.

(a) Ducts offered for inspection shall be factory run from which no ducts of superior quality have been removed.

(b) The ducts shall permit a mandrel eighteen (18) inches long and one-eighth (⅛) inch less than the specified inside dimension of the duct to pass freely through them.

(c) A section of finished duct weighing from three to four pounds broken so as to have all edges unglazed after being thoroughly dried and then immersed for twenty-four (24) hours in a sufficient quantity of water to just cover them and having a temperature of from sixty (60) to eighty (80) deg. Fahr. shall show an absorption of water of not more than five (5) per cent. of its weight.

(d) The water in which the broken pieces of ducts have been immersed shall not test either acid or alkaline with litmus paper after the completion of the immersion test.

FIBER CONDUIT.

10. Fiber Conduit.

Fiber conduit shall be made of finely divided wood pulp or fiber thoroughly impregnated with bituminous insulating compound. The compound shall not flow when the conduit has been heated to 212 deg. Fahr. for one hour, nor shall there be any separation into layers. The conduit shall not be affected by acids, alkalies or moisture and shall be free from all substances which might corrode or injure the sheath or rubber compound of a cable.

11. Walls.

The walls shall be hard and smooth and free from dents or obstructions, or excess of compound.

12. Dimensions.

The unit length of standard fiber conduit shall be five feet.

The inside and outside circumferences of any section of conduit including the joints shall not vary more than one-sixteenth ($\frac{1}{16}$) in. from a true circle at any temperature not exceeding 150 deg. Fahr.

The thickness of the conduit walls shall not be more than one-thirty-second ($\frac{1}{32}$) in. less or one-sixteenth ($\frac{1}{16}$) in. greater at any point than that given in Table I.

TABLE I—NOMINAL THICKNESS OF FIBER CONDUIT WALLS.

Nominal Inside Diameter	*Socket Joint*	*Drive Joint*	*Screw Joint*
1½ in.	¼ in.	¼ in.	5/16 in.
2 in.	¼ in.	¼ in.	3/8 in.
2½ in.	¼ in.	¼ in.	3/8 in.
3 in.	¼ in.	¼ in.	7/16 in.
3½ in.	¼ in.	¼ in.	7/16 in.
4 in.	¼ in.	¼ in.	1/2 in.

13. Test for Section.

Each piece of conduit shall permit the passage of a mandrel thirty-six (36) inches long and of a cross-section one-eighth (⅛) in. less than the nominal inside diameter of the conduit.

14. Socket Joints.

Socket joints shall have a mortise on one end and a tenon on the other end of each piece of conduit. The mortise and tenon shall be machine cut to produce a snug fit not less than three-eighths (⅜) in. long, slightly tapered and free from projecting surfaces, which would prevent the joint from being properly assembled. The thickness of the conduit wall left after the mortise and tenon have been turned shall be not less than one-thirty-second ($\frac{1}{32}$) in. less than one-half the nominal thickness of the wall.

15. Drive Joints.

Drive joints shall have smooth machine cut tapers on each end of each piece of conduit. The taper shall be four degrees to the axis of the conduit. For each joint there shall be furnished a sleeve of the same material as specified for the conduit, machine-cut to an internal taper at each end, the taper being the same as that specified for the conduit. The minimum thickness of the sleeve shall be not less than one-half the nominal thickness of the conduit. The tapers on the conduit and the sleeve shall be so cut that when the joint is made up the ends of the conduit shall not touch or be separated more than one-half (½) in.

The dimensions of the sleeves shall be within the following limits:

TABLE II—SLEEVE DIMENSIONS—DRIVE JOINTS.

Nominal Inside Diameter of Conduit	*Outside Diameter of Sleeve*		*Length of Sleeve*
	Not More Than	*Not Less Than*	*Not Less Than*
1½ in.	2⅜ in.	2$\frac{3}{16}$ in.	2$\frac{7}{16}$ in.
2 in.	2⅞ in.	2$\frac{11}{16}$ in.	3$\frac{7}{16}$ in.
2½ in.	3⅜ in.	3$\frac{3}{16}$ in.	3$\frac{7}{16}$ in.
3 in.	3⅞ in.	3$\frac{11}{16}$ in.	3$\frac{7}{16}$ in.
3½ in.	4⅜ in.	4$\frac{3}{16}$ in.	3$\frac{7}{16}$ in.
4 in.	4⅞ in.	4$\frac{11}{16}$ in.	3$\frac{7}{16}$ in.

16. Screw Joints.

Screw joints shall have a machine-cut thread on each end of each length of conduit. For each joint there shall be furnished a sleeve of the same material as specified for the conduit, having machine-cut thread to give an easy fit on the thread of the conduit. The minimum thickness of the sleeve shall be not less than three-quarters of nominal thickness of the conduit. The threads shall be cut and the ends of the conduit shall be faced so that the ends of the conduit will butt with a firm water-tight joint when the joint is screwed up firmly by hand, using a suitable bituminous compound. The threads shall be four to the inch.

TABLE III—SLEEVE DIMENSIONS—SCREW JOINTS.

Nominal Inside Diameter of Conduit	*Outside Diameter of Sleeve*		*Length of Sleeve*
	Not More Than	*Not Less Than*	*Not Less Than*
1½ in.	2¾ in.	2½ in.	$2\frac{5}{16}$ in.
2 in.	3½ in.	3¼ in.	$2\frac{15}{16}$ in.
2½ in.	4 in.	3¾ in.	$3\frac{7}{16}$ in.
3 in.	4⅝ in.	$4\frac{7}{16}$ in.	$3\frac{7}{16}$ in.
3½ in.	$5\frac{5}{16}$ in.	$4\frac{15}{16}$ in.	$3\frac{15}{16}$ in.
4 in.	5⅞ in.	$5\frac{13}{16}$ in.	$3\frac{15}{16}$ in.

17. Fittings and Bends.

Fittings and bends shall be made of the same material specified for fiber conduit and all requirements as to quality, material. dimensions, tests and joints shall apply thereto.

Bends shall have left-handed threads and sleeve for bends shall have one end threaded left-handed. All other threads shall be right-handed.

18. Short Pieces.

In each shipment there shall be included not less than five (5) nor more than fifteen (15) per cent. of pieces of conduit, less than the standard length of five (5) feet, but no conduit shall be furnished less than two and one-half (2½) feet in length.

19. Tests.

(a) A sample of conduit at seventy (70) deg. Fahr. resting on supports twenty-six (26) in. apart shall not exceed the deflection and shall not break under the load as shown in Table IV, when the load is centrally suspended between the supports.

(b) A six (6) in. sample of conduit at seventy (70) deg. Fahr. shall not be crushed when placed between two (2) flat surfaces under the pressure of a weight shown in the following table:

TABLE IV—DEFLECTION AND COMPRESSION TESTS.

Inside Diameter	*Thickness of Wall*	*Deflection*	*Deflection Test*	*Compression Test*
1½ in.	¼ in.	⅝ in.	200 lb.	475 lb.
2 in.	¼ in.	¾ in.	300 lb.	506 lb.
2½ in.	¼ in.	¾ in.	450 lb.	500 lb.
3 in.	¼ in.	¾ in.	550 lb.	347 lb.
3½ in.	¼ in.	⅝ in.	800 lb.	317 lb.
4 in.	¼ in.	⅝ iu.	900 lb.	310 lb.

(c) A six (6) in. sample of conduit shall be thoroughly dried at a temperature of one-hundred-ten (110) deg. Fahr. for four (4) hours, then weighed, and after immersion for forty-eight (48) hours in pure water at seventy (70) deg. Fahr. shall show less than four (4) per cent. increase in weight due to absorption of water.

General—Vitrified Clay Ducts and Fiber Conduits.

20. Inspection.

The Railroad may inspect the duct or conduit at any time during the process of manufacture and shall be furnished free of cost the necessary tools and appliances for making such tests as are necessary to determine if the requirements of these specifications have been met.

21. Packing and Marking.

Ducts when shipped in cars shall be carefully stacked, packed and braced.

Where shipped in less than carload lots they shall have the name of the Manufacturer, railroad order number and the shipping address plainly marked on a tag securely fastened to ten (10) per cent. of the pieces in the shipment.

Conduit Line Construction.

22. Trenching.

(a) Where necessary the trench shall be opened at points along the line of the proposed conduit line so that the nature and location of obstructions may be approximated and the grade line determined.

(b) The trench shall be excavated six (6) inches wider than the width of the section of the conduit line and deep enough to provide at least the earth protection specified in Section 3 (c).

(c) The trench shall be so graded that it will have a fall of at least three (3) inches in one hundred (100) feet towards the lower splicing chamber. The bottom of the trench shall closely follow the grade and be free from depressions, humps or other irregularities.

About ten feet back from the splicing chamber the grade shall be changed to permit the separation of the duct as described in Section 24 (d).

(d) After grading has been completed the trench shall be kept as reasonably free from water by draining, pumping or bailing as may be necessary in the judgment of the Engineer in charge.

(e) In making excavations parallel to the tracks of the Railroad the excavated material shall be piled on one side of the trench and trimmed back two (2) feet to provide necessary working clearance. Where the trench is adjacent to high speed tracks the side nearest the tracks shall be thoroughly braced to prevent the slipping of the roadbed. No bracing shall extend above the top of the rail or be attached in any way to the rails or ties.

23. Conduit Foundation.

The conduit foundation shall have a minimum thickness of four (4) inches for the full width of the trench, except where ledge rock is encountered, in which case the concrete foundation may be omitted and the bottom of the trench levelled with cement mortar. The concrete foundation shall be allowed to attain its initial set before ducts are laid thereon. The concrete shall conform to the Standard Specifications of the Railroad.

24. Laying Clay Ducts.

(a) A layer of mortar of necessary thickness to insure an even bearing shall be placed on the concrete foundation before placing the lower tier of ducts. The ducts shall be laid so as to break joints at least three (3) inches in the same tier and in each succeeding tier the joints shall be broken, the same amount with relation to the tier below.

(b) Ducts shall be carefully butted. Each joint shall be wrapped with a strip of burlap, cheesecloth or other wrapper of quality approved by the Engineer in charge, not less than six (6) inches wide saturated with neat Portland cement mortar and laid equally over the abutting ducts. The ends of the strip shall lap not less than six (6) inches on top. These wraps shall be double on curves and also where concrete encasing is placed simultaneously with the laying of the ducts.

(c) The joints shall be plastered with one-half (½) inch layer of mortar. A layer of mortar of necessary thickness shall be placed underneath each succeeding tier of ducts as laid.

(d) Commencing about ten feet back from the splicing chamber the ducts shall be gradually separated both vertically and horizontally so that there will be a separation of four (4) inches where they enter the splicing chamber. Only eighteen (18) inch or twelve (12) inch ducts shall be used at the entrance to splicing chambers. Short lengths necessary for this adjustment shall be used further out in the section. Where the ducts are cut to special lengths the cut shall be dressed with a chisel and rasped until the hole is slightly bell mouthed and has smooth edges to conform closely to the original design.

(e) Wherever the work is suspended leaving incompleted tiers the free ends of the ducts shall be closed with tapered wood or other approved plugs which shall conform accurately to the shape of the opening and be of such size at the large end that they cannot be forced entirely within the opening. Where the conduit lines pass over quicksand or other unstable ground, the concrete foundation shall be specially reinforced or supported.

25. Concrete Protection.

The duct line shall be encased with concrete which shall be not less than three (3) inches thick on the sides and four (4) inches over the top. The concrete shall be allowed to attain its initial set and preferably its final set before the trench is filled in.

LAYING FIBER CONDUITS.

26. Laying Fiber Conduits.

(a) A layer of mortar of necessary thickness to ensure an even bearing shall be placed on the concrete foundation before placing the lower tier of conduits. One tier shall be laid at a time with all joints staggered at least six (6) inches as between adjacent conduits and tiers of conduits. Spacers shall be used between conduits so as to maintain a separation of at least one (1) inch, both vertically and horizontally. These shall be removed as the pouring of the concrete nears them.

(b) After the first tier of conduit is laid one (1) inch of concrete shall be placed thereon extending three (3) inches beyond the side of the conduit line. Succeeding tiers of conduit shall be laid in a similar manner with one (1) inch of concrete laid over each tier except the upper tier. After the upper tier has been placed a four (4) inch layer of concrete shall be poured on top of the last layer of conduit.

(c) The concrete shall be carefully placed so as not to disturb the conduits or to injure the joints in any way when tamping is being done.

(d) Where either the socket, sleeve or screw joint type of conduit is used the joints shall be treated with a joint paste or compound. The paste or compound shall not act injuriously on the conduit or on the sheaths or rubber insulation of cables. Extreme care shall be taken to exclude the paste or compound from the interior of the conduits.

27. Joining Different Ducts.

Where a change from one style or size of duct to another is necessary it shall be made at a splicing chamber.

28. Back Filling.

Back filling shall be done in layers and each layer shall be thoroughly tamped without flushing. Where openings have been made through paving, sidewalls or platforms, they shall be brought to a grade three (3) or four (4) inches above the existing grade until after the replacements have been made.

29. Clearing.

Materials, boulders and rubbish incidental to the construction shall be removed as the work will permit and at its completion the site shall be left clean and unobstructed.

30. Cleaning and Rodding.

After the conduit line has been completed and the concrete enclosing it well set the ducts shall be cleaned and rodded by using a steel plunger, a steel wire flue brush and wood mandrel in the order named. All mortar or other foreign substance shall be removed from the conduit line, leaving clean, smooth surfaces inside the ducts. If obstructions are found in rodding the ducts which cannot be removed by cleaners so as to give a clean, smooth opening one-eighth (⅛) inch less than the nominal size of the duct for the entire length between adjacent splicing chambers, the conduit lines shall be opened up and the obstruction removed and the ducts replaced.

SPLICING CHAMBERS.

31. General.

(a) Splicing chambers shall be located where indicated on the plans and shall be of the type shown on the accompanying drawings. The modifications necessary to suit local conditions shall be subject to the approval of the Engineer in charge.

(b) Splicing chambers shall preferably be made of concrete. Where concrete splicing chambers are not practicable, hard burned brick laid with Portland cement mortar joints shall be used.

(c) The splicing chambers shall generally be spaced from four hundred (400) to five hundred (500) feet apart, depending on the size and weight of cable to be installed.

(d) Splicing chambers shall be so located as to provide safe and ready access and in general shall be built so that no part of the cover of a manhole is less than three (3) feet measured horizontally from the nearest rail. Splicing chambers shall, where possible, be located in dips or depressions in the conduit line so that drainage will be naturally toward them. The lower tier of ducts shall enter the splicing chambers at not less than eight (8) inches above the floor and the upper tier not less than eight (8) inches below the roof.

(e) Pulling-in irons shall be located as shown on the drawings. The manhole shall be circular in form and not less than thirty inches in diameter. It shall, where practicable, be placed in the center of the splicing chamber roof.

32. Dimensions of Splicing Chambers.

The dimensions of splicing chambers shall be determined by the number of ducts entering them, the character and importance of the installation and local conditions.

The dimensions of typical splicing chambers are shown in the following table:

TABLE V—TWO-WAY SPLICING CHAMBERS.

No. of Ducts	*(A)*	*(B)*	*(C)*
9 or less	8′-0″	5′-0″	6′-6″
10 to 16	9′-0″	6′-0″	7′-0″
	Three-Way Splicing Chambers		
9 or less	8′-0″	8′-0″	6′-6″
10 to 16	9′-0″	10′-0″	7′-0″
	Four-Way Splicing Chambers		
9 or less	7′-0″	10′-0″	6′-6″
10 to 16	8′-0″	11′-0″	7′-0″

33. Excavation for Splicing Chambers.

Where outside forms are not used, the excavation shall be made to conform with the outside dimensions of the splicing chambers.

Where outside forms are used or the splicing chamber is to be constructed of brick, excavation shall be at least eight (8) inches greater than the outside dimensions.

34. Walls.

(a) Walls shall be of a thickness necessary for local conditions and will be shown on plans.

(b) Where brick construction is used, every third course shall be headers. Brick bats shall not be used. At horizontal joints, the mortar shall not exceed one-half inch in thickness and at vertical joints three-eighths inch in thickness.

(c) The thickness of concrete and brick walls may be increased or decreased from the dimensions shown on the plans to fit local conditions, with the approval of the Engineer in charge.

(d) Where splicing chamber walls are within eight feet of the nearest rail of railroad tracks, the walls shall be designed so as to take care of the additional loads imposed upon them.

35. Floors.

The floors shall preferably be of concrete and placed at the same time that the walls are built. If the manhole is of brick construction, the floor shall be either of concrete four inches thick, or of grouted brick.

36. Cable Hangers.

Provision shall be made for supporting the cables in the splicing chambers. A method is described below and illustrated on Plate No. 8.

(a) *Racks*—Each rack shall be made of not less than one-quarter (¼) inch angle iron punched or drilled and galvanized or sherardized. The racks shall be fastened to the splicing chamber wall by galvanized or sherardized bolts which are to be set in the side wall.

(b) *Hangers*—Each rack shall be provided with a number of single or double cast iron cable hangers, of design shown on drawings, as the Engineer in charge may direct. Each hanger shall be made of good quality tough grey iron made by the cupola process and shall be true to dimensions, smooth, clean and free from blow holes and other injurious imperfections. Each hanger shall be fastened to the rack with a bolt. Each hanger shall be given one coat of an approved moisture resisting paint before and after installation or otherwise protected from corrosion, as may be directed by the Engineer in charge.

(c) *Insulators*—Cable hangers shall be provided with semi-porcelain insulators, glazed on all surfaces and shall be smooth and free from cracks, flaws, chipped surfaces or other injurious imperfections.

37. Manhole Covers and Frames.

Frames and covers shall be of tough grey iron, free from injurious cold-shuts, shrinkage strains, blow holes or other imperfections, and shall be true to dimensions and workmanlike in finish. The frames and covers shall conform with the size and type indicated on the drawings.

38. Drains.

A back pressure valve and trap with perforated inlet and guard, subject to approval of the Engineer in charge, shall be furnished and placed as designated or as indicated on the drawing, and the same shall be properly connected by means of a pipe with the main sewer, or with gutter drains or ditches at the nearest practicable point.

39. Anchor Bolts.

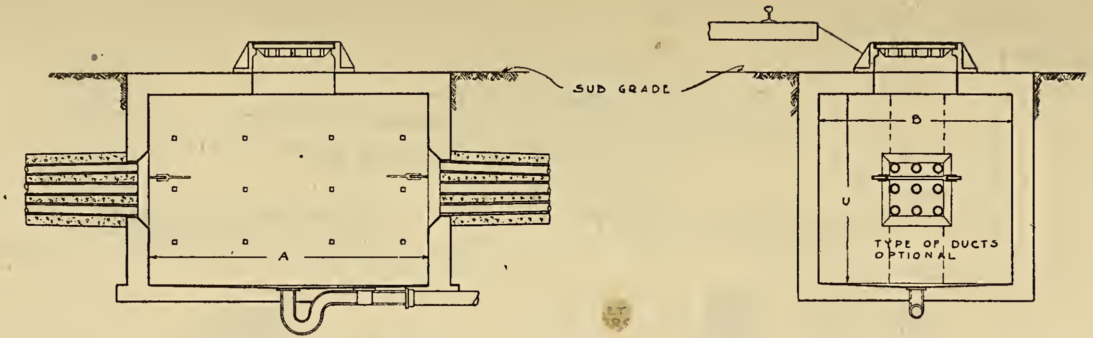
Anchor bolts in walls of splicing chambers and the pulling-in irons shall conform to dimensions called for on the plans, and shall be of material similar to that covered by specifications for bridge iron.

40. Reinforcing Bars.

Reinforcing bars to be used in the construction of the roof of splicing chambers and for reinforcing walls, when necessary, shall conform with the standard specifications for reinforcing bars.

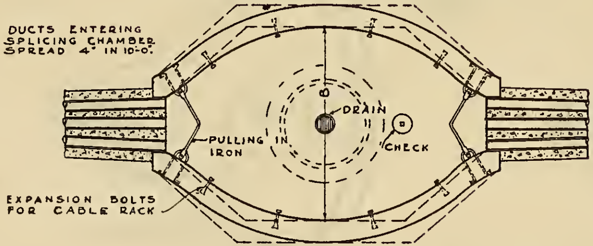
41. Structural Steel.

Structural steel when indicated as necessary on the drawings, shall conform to Railroad standard specifications for this class of material.



LONGITUDINAL SECTION

TRANSVERSE SECTION


DUCTS ENTERING SPLICING CHAMBER SPREAD 4" IN 10-0".
EXPANSION BOLTS FOR CABLE RACK
PULLING IN IRON
DRAIN
CHECK
B

SECTIONAL PLAN

FORM OF SECTION OPTIONAL.

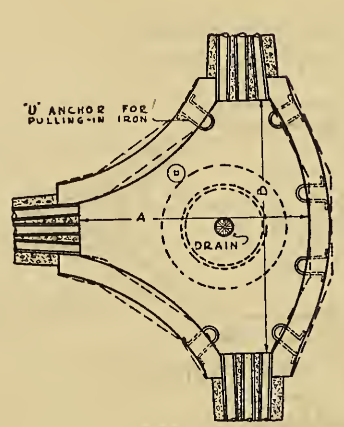
NOTE:—
CONCRETE TO BE REINFORCED WHERE NECESSARY.

COMMITTEE ON ELECTRICITY.

TYPICAL 2-WAY SPLICING CHAMBER.

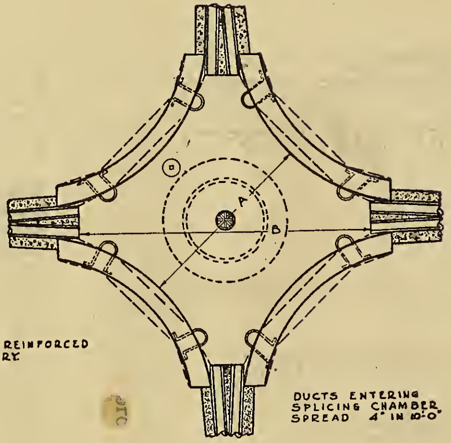
OCTOBER 1920.

PLATE No. 1.



SECTIONAL PLAN
FORM OF SECTION OPTIONAL

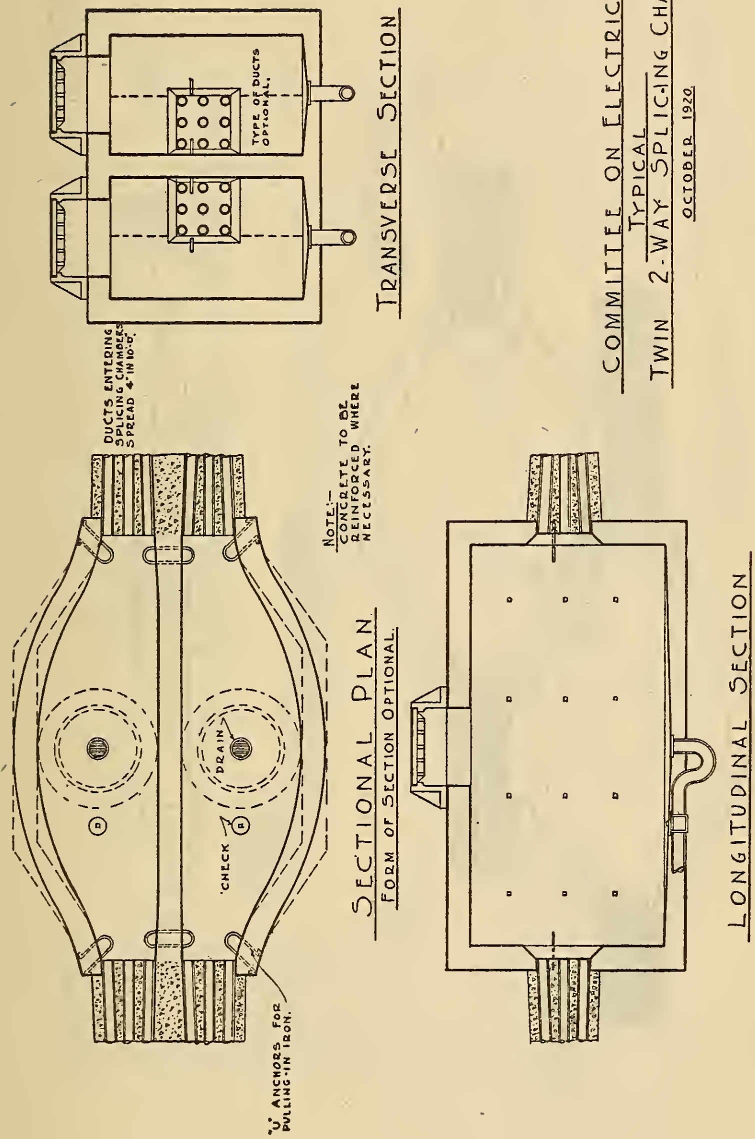
NOTE:-
CONCRETE TO BE REINFORCED WHERE NECESSARY.



SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.

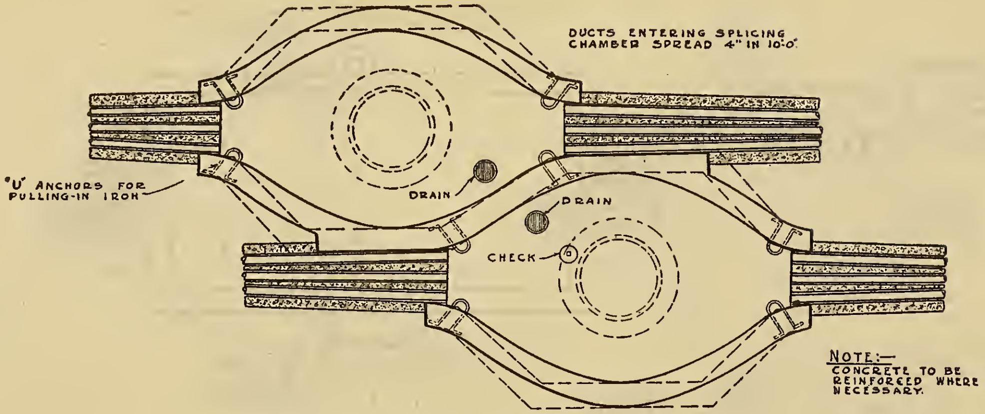
COMMITTEE ON ELECTRICITY.
TYPICAL 3 AND 4-WAY SPLICING CHAMBER
OCTOBER 1920.

PLATE No. 2.


TRANSVERSE SECTION
TYPE OF DUCTS OPTIONAL.
DUCTS ENTERING SPLICING CHAMBERS SPREAD 4" IN 10'-0".
NOTE:— CONCRETE TO BE REINFORCED WHERE NECESSARY.
SECTIONAL PLAN
FORM OF SECTION OPTIONAL.
DRAIN
CHECK
"U" ANCHORS FOR PULLING-IN IRON.
LONGITUDINAL SECTION

COMMITTEE ON ELECTRICITY.
TYPICAL
TWIN 2-WAY SPLICING CHAMBER
OCTOBER 1920

PLATE No. 3.

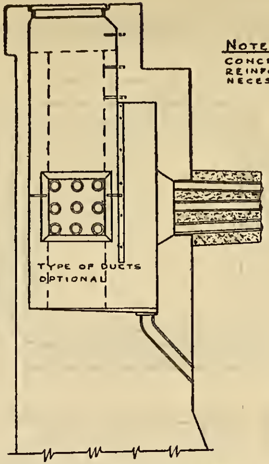

DUCTS ENTERING SPLICING CHAMBER SPREAD 4" IN 10'0"
"U" ANCHORS FOR PULLING-IN IRON
DRAIN
DRAIN
CHECK

NOTE:—
CONCRETE TO BE REINFORCED WHERE NECESSARY.

SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.

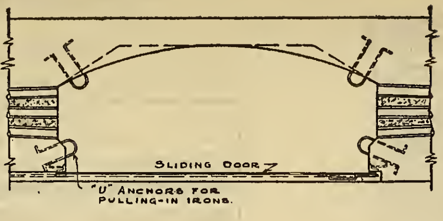
COMMITTEE ON ELECTRICITY.
TYPICAL TANDEM 2-WAY SPLICING CHAMBER.
OCTOBER 1920.

PLATE NO. 4.

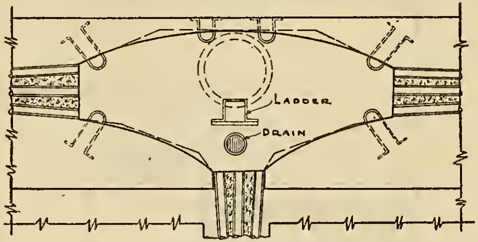


SPLICING CHAMBER AT TOP OF WALL
TRANSVERSE SECTION

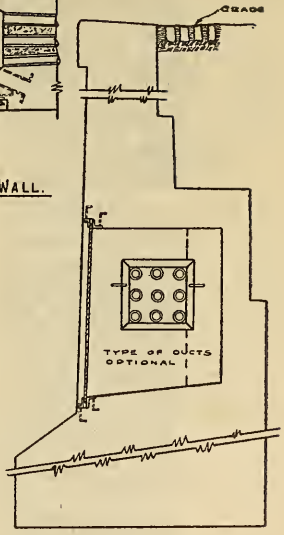
NOTE:—
CONCRETE TO BE REINFORCED WHERE NECESSARY.


DUCTS ENTERING SPLICING CHAMBERS SPREAD 4" IN 10'-0"
SLIDING DOOR
"U" ANCHORS FOR PULLING-IN IRONS.

SPLICING CHAMBER BELOW TOP OF WALL.
SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.



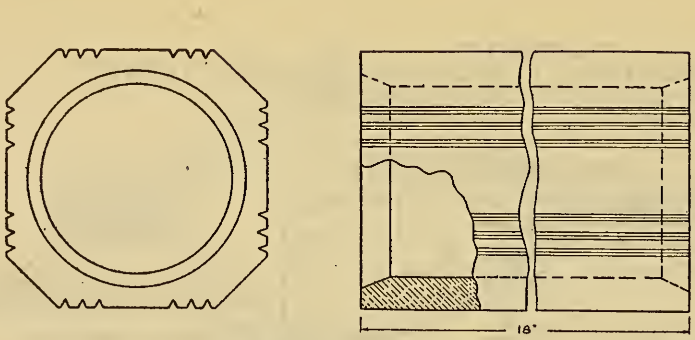
SPLICING CHAMBER AT TOP OF WALL.
SECTIONAL PLAN.
FORM OF SECTION OPTIONAL.



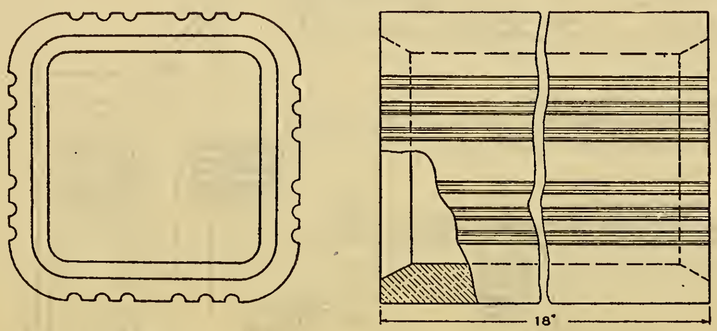
SPLICING CHAMBER BELOW TOP OF WALL.
TRANSVERSE SECTION.

COMMITTEE ON ELECTRICITY
TYPICAL SPLICING CHAMBERS IN CONCRETE RETAINING WALLS.
OCTOBER 1920.

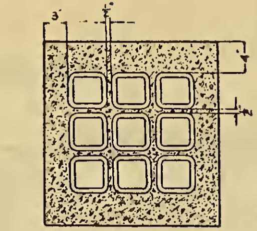
PLATE NO. 5.



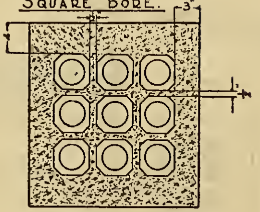
3½" ROUND TILE DUCT OR CONDUIT.



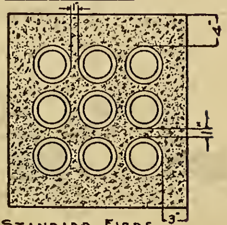
3½" SQUARE TILE DUCT OR CONDUIT.



STANDARD VITRIFIED CLAY DUCT SECTION SQUARE BORE.



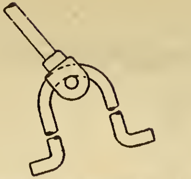
STANDARD VITRIFIED CLAY DUCT SECTION ROUND BORE.



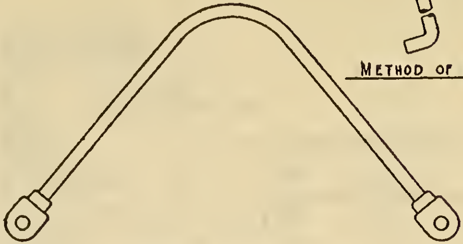
STANDARD FIBRE CONDUIT SECTION.

COMMITTEE ON ELECTRICITY.
OCTOBER 1920.

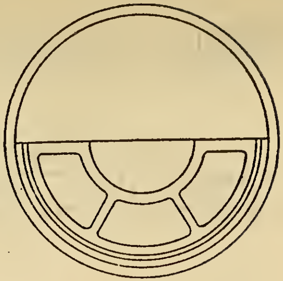
PLATE NO. 6.



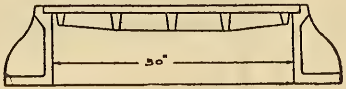
METHOD OF MAKING CONNECTION.



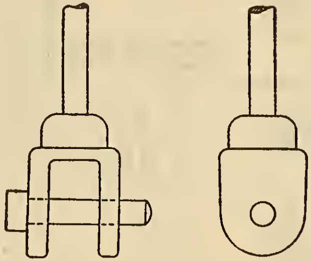
PULLING-IN IRON.



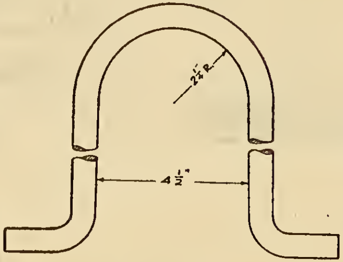
MANHOLE COVER



MANHOLE FRAME



DETAILS OF PULLING-IN IRON.

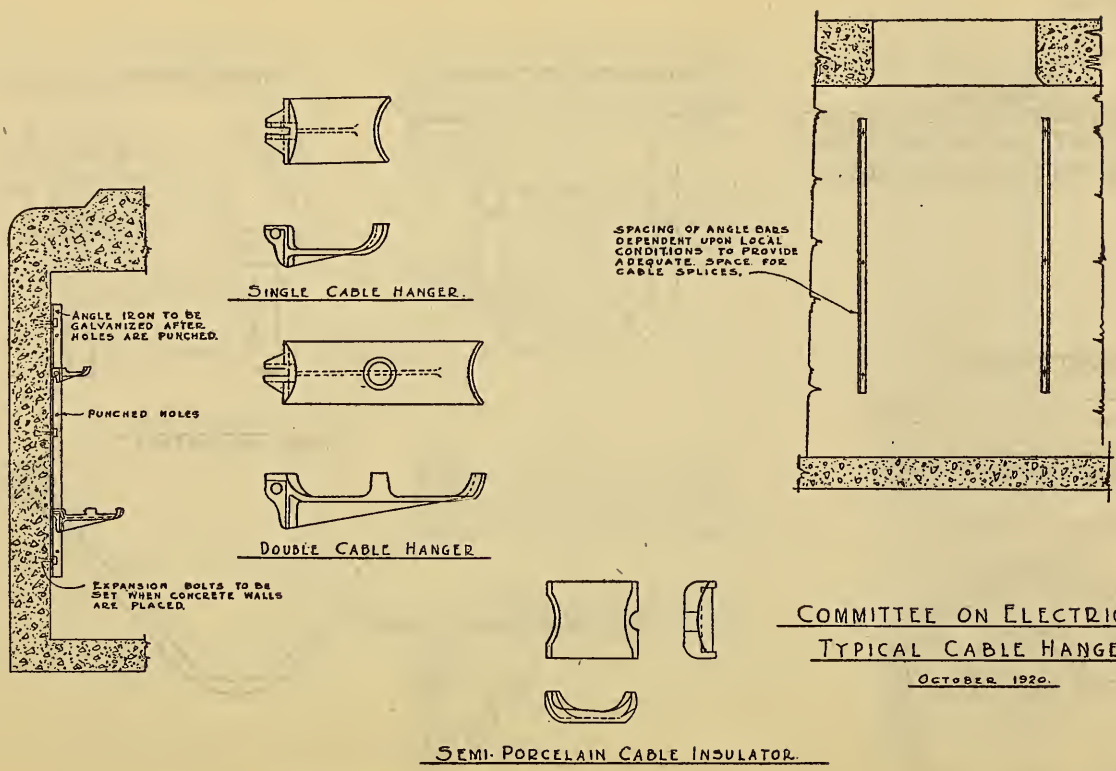


DETAIL OF "U" ANCHORS.

COMMITTEE ON ELECTRICITY.

DETAILS OF PULLING-IN IRON AND
MANHOLE COVER FOR SPLICING CHAMBER.
OCTOBER 1920

PLATE NO. 7.


Spacing of angle bars dependent upon local conditions to provide adequate space for cable splices.
Single Cable Hanger.
Angle iron to be galvanized after holes are punched.
Punched holes
Double Cable Hanger
Expansion bolts to be set when concrete walls are placed.
Semi-Porcelain Cable Insulator.

COMMITTEE ON ELECTRICITY.
TYPICAL CABLE HANGERS.
OCTOBER 1920.

PLATE No. 8.

[8] TUNGSTEN LAMP STANDARDS—1920.

Illumination.

Size in Watts	*Voltages*	*Type and Size of Bulb*	*Base Type*		*Remarks*
10	110, 115, 120, 125	S. 14	Med. Screw	B	
15	“ “ “ “	S. 17	“ “	B	
25	“ “ “ “	S. 17	“ “	B	
50	“ “ “ “	S. 19	“ “	B	
75	“ “ “ “	P. S. 22	“ “	C	
100	“ “ “ “	P. S. 25	“ “	C	
150	“ “ “ “	P. S. 25	“ “	C	
200	“ “ “ “	P. S. 30	“ “	C	
250	“ “ “ “	G. 30	“ “	C	Used for flood lighting, Concentrated filament for focusing.
300	“ “ “ “	P. S. 35	Mogul	C	
500	“ “ “ “	G. 40	“	C	do
500	“ “ “ “	P. S. 40	“	C	
750	“ “ “ “	P. S. 52	“	C	
1000	“ “ “ “	P. S. 52	“	C	
25	220, 230, 240, 250	S. 19	Med. Screw	B	
50	“ “ “ “	S. 19	“ “	B	
100	“ “ “ “	S. 30	“ “	B	
200	“ “ “ “	P. S. 30	“ “	C	
300	“ “ “ “	P. S. 35	Mogul	C	
500	“ “ “ “	P. S. 40	“	C	
1000	“ “ “ “	P. S. 52	“	C	

Mill Type.

25	110, 115, 120, 125	S. 19	Med. Screw	B	
50	“ “ “ “	S. 19	“ “	B	

Car Axle Lighting.

15	32-64	(*) S. 17 G. 18½	“ “	B	
25	“ “	(*) S. 17 G. 18½	“ “	B	
50	“ “	(*) S. 19 G. 30	“ “	B	
25	“ “	P. S. 20	“ “	C	Will be standardized to replace the type B lamp at a future time.
50	“ “	P. S. 20	“ “	C	“White” bulb may also be used.
75	“ “	P. S. 22	“ “	C	
100	“ “	P. S. 25	“ “	C	

Motor and Trailer Car and Locomotive Lighting and Headlights.

15	33	S. 17	Med. Screw	B	Cab Lighting.
23	110, 115, 120, 125, 130	S. 17	“ “	B	Series.
36	“ “ “ “ “	S. 19	“ “	B	“
56	“ “ “ “ “	S. 21	“ “	B	“
94	“ “ “ “ “	S. 24½	“ “	B	“
100	32	G. 25	“ “	C	Headlight.
250	32	G. 30	“ “	C	“

(*) An extra charge of about 30 per cent. is usually made for the “G” style.

[8] Adopted, Vol. 22, 1921, pp. 146, 970.

COMMITTEE XIX.

CONSERVATION OF NATURAL RESOURCES.

[1] RULES FOR THE PREVENTION OF THE SPREAD OF FOREST AND FIELD FIRES.

Precautionary Measures.

1. Railroads shall not permit fires, burning waste, live coals, ashes, wood or other substances in a burning state to be deposited on tracks or right-of-way, unless such fires are completely extinguished immediately thereafter; except where such fires are deposited in pits provided for that purpose, or deposited on parts of track specially designated as being safe for such purpose.

2. Railroads shall take the necessary measures to maintain tracks and right-of-way in safe condition to prevent the spread of forest, prairie and field fires.

Preventive measures shall be taken in all cases where coal- or wood-burning locomotives are operated through districts where there is possibility of fire running. In general, such measures shall be as follows:

Disposal of Inflammable Material.

(a) All inflammable material, such as standing dead trees, logs, dead or decayed wood, brush, dry leaves and dry grass, within the limits of the right-of-way, shall be burned off early in the spring months, and as often thereafter as may be deemed necessary.

Supervision of Burning Operations.

3. No railroad, through its agents, employees, or contractors, shall burn, or cause to be burned, any cross- or switch-ties, mowings, debris, or other litter on or near the right-of-way except under proper supervision, to prevent such fires from spreading beyond control. During the period of greatest fire danger, no such burning shall be done by the railroad forces.

Reporting Fires.

4. Railroads shall instruct and require stationmen and other employees, agents, or contractors, to report fires and extinguish same when on or adjacent to the right-of-way, as follows:

(a) Enginemen, conductors, or trainmen, who discover or receive notice of a fire burning upon or adjacent to the right-of-way, or of a fire which threatens land or property located adjacent to the right-of-way shall report its existence and exact location by milepost to the agent or person in charge at the nearest point where communication by telegraph or telephone is available, and also notify the first section employees passed.

---

[1] Adopted, Vol. 21, 1920, pp. 292, 1381.

Notice of such fire shall also be given immediately by enginemen by a system of warning whistles.

(b) The agent or other employee of the railroad shall at once notify the nearest section employees, and, if possible, the nearest Federal or State Forest Fire official, of the existence and exact location by milepost of such fire.

(c) When a fire is reported or discovered burning adjacent to the right-of way of a railroad, regardless of its origin, such sectionmen or other employees of the railroad as are available shall at once proceed to the location of the fire and extinguish it, provided such sectionmen or other employees at the time are not engaged in work essential to the safe operation of trains.

(d) Railroads operating through forest districts shall provide suitable blank forms for reporting fires occurring on or adjacent to the railroad right-of-way, regardless of their origin. Section foremen shall be instructed and required to make detailed written report on the prescribed form of any fire, however trivial, and to forward such reports promptly to their superior. The intent of this rule is to determine and, if possible, to eliminate the causes of fire.

Special Instructions.

5. Railroads shall issue special instructions to employees concerning the foregoing rules or regulations. Such rules or regulations shall be posted on bulletin boards at engine houses, section houses, stations, and in conspicuous places on other parts of the right-of-way of the railroad.

Co-operation with Other Agencies.

6. In view of the aid that may be rendered by the various State Forest Fire Protective organizations, the officers of the Forest Service of the United States Department of Agriculture, and Timber Owners' Protective organizations, the closest possible co-operation by railroads with such agencies, wherever they exist, is desired and encouraged. The details of such co-operation between the railroad forces and the protective organizations is to be arrived at by mutual agreement between the parties concerned.

Minimum Requirements.

7. The foregoing rules or regulations constitute minimum requirements. It is not intended that they shall supersede state laws or regulations where additional measures are in effect, but they are supplementary thereto.

UNIFORM GENERAL CONTRACT FORMS.

[1] FORM OF PROPOSAL.

.... 19....

....the undersigned propose to furnish all the materials, superintendence, labor, equipment and transportation, except as otherwise specified, and to execute, construct and finish in an expeditious, substantial and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer........

....

....

....

....

....

....

and agree to commence the work within .... days after receipt of the notice of award of the contract, and to complete the work within .... days thereafter, in accordance with the terms, conditions, requirements and specifications covered by the request for proposals made by .... dated ....
for the following prices:

....

....

....

....

....

....

(Signed) ....

---

[1] Adopted, Vol. 15, 1914, pp. 921, 1155.

[2] FORM OF CONSTRUCTION CONTRACT.

A—AGREEMENT.

THIS AGREEMENT, made this .... day of .... in the year .... by and between ....
....
party of the first part, hereinafter called the Contractor, and ....
.... party of the second part, hereinafter called the Company:

WITNESSETH, That, in consideration of the covenants and agreements hereinfter mentioned, to be performed by the parties hereto, and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The Contractor shall furnish all the materials, superintendence, labor, equipment and transportation, except as hereinafter specified, and shall execute, construct and finish, in an expeditious, substantial and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer of the Company...
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

---

[2] Adopted, Vol. 14, 1913, pp. 699-709, 1144-1164; Vol. 15, 1914, pp. 921, 1155; Vol. 16, 1915, pp. 92, 1037; Vol. 17, 1916, pp. 299, 860; Vol. 22, 1921, pp. 251, 994.

in accordance with the plans hereto attached identified by the signatures of the parties hereto, or herein described, and the following general conditions, requirements and specifications, forming part of this contract.

The work covered by this contract shall be commenced ....
.... and be completed on or before the
.... day of .... 19................................
....
time being of the essence of this contract ....
....
....

And in consideration of the completion of the work described herein, and the fulfillment of all stipulations of this agreement to the satisfaction and acceptance of the Chief Engineer of the Company, the said Company shall pay, or cause to be paid, to said Contractor, the amount due to the Contractor, based on the following prices:

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

This agreement shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively.

In Witness Whereof, The parties hereto have executed this agreement in .... the day and year first above written.

Witness:

....
....
....
....
....
....

CONSTRUCTION CONTRACT.

B—General Conditions.

Bond.

1. The contractor shall, at the time of the execution and delivery of this contract, and before the taking effect of the same in other respects, furnish and deliver to the Company a written bond of indemnity to the amount of...........dollars, in form and substance and with surety thereon satisfactory and acceptable to the Company, to insure the faithful performance by the Contractor of all the covenants and agreements on the part of the Contractor contained in this contract.

This bond shall remain in force and effect for the full amount or such smaller sum as may at any time be specified by the Chief Engineer.

Contractor's Understanding.

2. It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this contract. No verbal agreement or conversation with any officer, agent or employee of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

Intent of Plans and Specifications.

3. All work that may be called for in the specifications and not shown on the plans, or shown on the plans and not called for in the

specifications, shall be executed and furnished by the Contractor as if described in both these ways; and should any work or material be required which is not denoted in the specifications or plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intent thereof, the Contractor is to understand the same to be implied and required, and shall perform all such work and furnish any such material as fully as if they were particularly delineated or described.

Permits.

4. Permits of a temporary nature necessary for the prosecution of the work shall be secured by the Contractor. Permits for permanent structures or permanent changes in existing facilities shall be secured by the Company.

Protection.

5. Whenever the local conditions, laws or ordinances require, the Contractor shall furnish and maintain, at his own cost and expense, necessary passageways, guard fences and lights and such other facilities and means of protection as may be required.

Rights of Various Interests.

6. Wherever work being done by Company forces or by other contractors is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

Consent to Transfer.

7. The Contractor shall not let or transfer this contract or any part thereof (except for the delivery of material) without consent of the Chief Engineer, given in writing. Such consent does not release or relieve the Contractor from any of his obligations and liabilities under the contract.

Superintendence.

8. The Contractor shall constantly superintend all of the work embraced in this contract, in person or by a duly authorized manager acceptable to the Company.

Timely Demand for Points and Instructions.

9. The Contractor shall provide reasonable and necessary opportunities and facilities for setting points and making measurements. He shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be

necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

Report Errors and Discrepancies.

10. If the Contractor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors or omissions in plans or in the layout as given by said points and instructions, it shall be his duty to immediately inform the Engineer, in writing, and the Engineer shall promptly verify the same. Any work done after such discovery, until authorized, will be done at the Contractor's risk.

Preservation of Stakes.

11. The Contractor must carefully preserve bench marks, reference points and stakes, and in case of wilful or careless destruction, he will be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

Inspection.

12. All work and material shall be at all times open to the inspection, acceptance or rejection of the Engineer or his authorized representative. The Contractor shall give the Engineer reasonable notice of starting any new work and shall provide reasonable and necessary facilities for inspection, even to the extent of taking out portions of finished work; in case the work is found satisfactory, the cost of taking out and replacement shall be paid by the Company. No work shall be done at night without the previous approval of the Engineer.

Defective Work or Material.

13. Any omissions or failure on the part of the Engineer to disapprove or reject any work or material shall not be construed to be an acceptance of any defective work or material. The Contractor shall remove, at his own expense, any work or material condemned by the Engineer, and shall rebuild and replace the same without extra charge, and in default thereof the same may be done by the Company at the Contractor's expense, or, in case the Chief Engineer shall not consider the defect of sufficient importance to require the Contractor to rebuild or replace any imperfect work or material, he shall have power, and is hereby authorized, to make an equitable deduction from the stipulated price.

Insurance.

14. The Contractor shall secure in the name of the Company, policies of fire insurance in amount, form and companies, satisfactory to the

Chief Engineer, upon such structures and material as shall be specified by the latter, payable to the Company for the benefit of the Contractor or the Company, as the Chief Engineer shall find their interests to appear.

Indemnity.

15. The Contractor shall indemnify and save harmless the Company from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against it, by reason of any act or omission of the said Contractor, his agents or employees, in the execution of the work or in consequence of any negligence or carelessness in guarding the same.

Settlement for Wages.

16. Whenever, in the opinion of the Chief Engineer, it may be necessary for the progress of the work to secure to any of the employees engaged on the work under this contract any wages which may then be due them, the Company is hereby authorized to pay said employees the amount due them or any lesser amount, and the amount so paid them, as shown by their receipts, shall be deducted from any moneys that may be or become payable to said Contractor.

Liens.

17. If at any time there shall be evidence of any lien or claim for which the Company might become liable, and which is chargeable to the Contractor, the Company shall have the right to retain out of any payment then due or thereafter to become due, an amount sufficient to completely indemnify the Company against such lien or claim, and if such lien or claim be valid, the Company may pay and discharge the same, and deduct the amount so paid from any moneys which may be or become due and payable to the Contractor.

Work Adjacent to Railroad.

18. Wherever the work embraced in this contract is near the tracks, structures or buildings of this Company or of other railroads, the Contractor shall use proper care and vigilance to avoid injury to persons or property. The work must be so conducted as not to interfere with the movement of trains or other operations of the railroad; or, if in any case such interference be necessary, the Contractor shall not proceed until he has first obtained specific authority and directions therefor from the proper designated officer of the Company and has the approval of the Engineer.

Risk.

19. The work under this contract in every respect shall be at the risk of the Contractor until finished and accepted, except damage or injury caused directly by Company's agents or employees.

Order and Discipline.

20. The Contractor shall at all times enforce strict discipline and good order among his employees, and any employee of the Contractor who shall appear to be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer, and he shall not again be employed on the work without the Engineer's written consent.

Contractor Not to Hire Company's Employees.

21. The Contractor shall not employ or hire any of the Company's employees without the permission of the Engineer.

Intoxicating Liquors Prohibited.

22. The Contractor, in so far as his authority extends, shall not permit the sale, distribution or use of any intoxicating liquors upon or adjacent to the work, or allow any such to be brought upon, to or near the property of the Company.

Cleaning Up.

23. The Contractor shall, as directed by the Engineer, remove from the Company's property and from all public and private property, at his own expense, all temporary structures, rubbish and waste materials resulting from his operations.

Engineer and Chief Engineer.

24. Wherever in this contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.

Power of Engineer.

25. The Engineer shall have power to reject or condemn all work or material which does not conform to this contract; to direct the application of forces to any portion of the work which, in his judgment, requires it; to order the force increased or diminished, and to decide questions which arise between the parties relative to the execution of the work.

Adjustment of Dispute.

26. All questions or controversies which may arise between the Contractor and the Company, under or in reference to this contract, shall be subject to the decision of the Chief Engineer, and his decision shall be final and conclusive upon both parties.

Order of Completion; Use of Completed Portions.

27. The Contractor shall complete any portion or portions of the work in such order of time as the Engineer may require. The Company shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of the work so taken or used or any part thereof. If such prior use increases the cost of or delays the work, the Contractor shall be entitled to such extra compensation, or extension of time, or both, as the Chief Engineer may determine.

Changes.

28. The Company shall have the right to make any changes that may be hereafter determined upon, in the nature or dimensions of the work, either before or after its commencement, and such changes shall in no way affect or void the obligations of this contract. If such changes make any change in the cost of the work, an equitable adjustment shall be made by the Chief Engineer to cover the same.

Extra Work.

29. No bill or claim for extra work or material shall be allowed or paid unless the doing of such extra work or the furnishing of such extra material shall have been authorized in writing by the .... Engineer.

The price for such work shall be determined by the Chief Engineer, who may either fix a unit price or a lump-sum price, or may, if he so elects, provide that the price shall be determined by the actual cost, to which shall be added .... per cent. to cover general expense and superintendence, profits, contingencies, use of tools, Contractor's risk and liability. If the Contractor shall perform any work or furnish any material which is not provided for in this contract, or which was not authorized in writing by the Engineer, said Contractor shall receive no compensation for such work or material so furnished, and does hereby release and discharge the Company from any liability therefor.

If the Contractor shall proceed with such extra work or the furnishing of such extra material after receiving the written authority therefor, as hereinbefore provided, then such work or material, stated in the written authority of the Engineer, shall be covered, governed and controlled by all the terms and provisions of this contract, subject to such prices as may be agreed upon or fixed by the Chief Engineer.

If the Contractor shall decline or fail to perform such work or furnish such extra material as authorized by the Engineer in writing, as aforesaid, the Company may then arrange for the performance of the work in any manner it may see fit, the same as if this contract had not been executed, and the Contractor shall not interfere with such performance of the work.

Land of Company, Use of, by Contractor.

30. The Company shall provide the land upon which the work under this contract is to be done, and will, so far as it can conveniently do so, permit the Contractor to use so much of its land as is required for the erection of temporary construction facilities and storage of materials, together with the right of access to same, but beyond this the Contractor shall provide, at his cost and expense, any additional land required.

Unavoidable Delays; Extension of Time on Parts of Work.

31. If the Contractor shall be delayed in the performance of the work from any cause for which the Company is responsible, he shall, upon written application to the Chief Engineer at the time of such delay, be granted such extension of time as the Chief Engineer shall deem equitable and just.

Suspension of Work.

32. The Company may at any time stop the work, or any part thereof, by giving .... days' notice to the Contractor in writing. The work shall be resumed by the Contractor in ten (10) days after the date fixed in the written notice from the Company to the Contractor so to do. The Company shall not be held liable for any damages or anticipated profits on account of the work being stopped, or for any work done during the interval of suspension. It will, however, pay the Contractor for expense of men and teams necessarily retained during the interval of suspension, provided the Contractor can show that it was not reasonably practicable to move these men and teams to other points at which they could have been employed. The Company will further pay the Contractor for time necessarily lost during such suspension at the rate of .... per cent. per annum on the estimated value of

materials, equipment and fixtures furnished by the Contractor on the work which are necessarily idle during such suspension, said rate of ………… per cent. per annum being understood to include depreciation, interest and insurance. But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Company does not give notice in writing to the Contractor to resume work at a date within …………………… of the date fixed in the written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for work done, on such portion so abandoned, as provided in Section 38 of this contract.

Expediting Work, Correcting Imperfections.

33. (a) If the Chief Engineer of the Company shall at any time be of the opinion that the Contractor is neglecting to remedy any imperfections in the work, or is not progressing with the work as fast as necessary to insure its completion within the time and as required by the contract, or is otherwise violating any of the provisions of this contract, said Chief Engineer, in behalf of the Company, shall have the power, and it shall be his duty to notify the Contractor to remedy such imperfections, proceed more rapidly with said work, or otherwise comply with the provisions of this contract.

Annulment.

(b) In such case the Company may give the Contractor ten (10) days' written notice, and at the end of that time, if the Contractor continues to neglect the work, the Company may provide labor and materials and deduct the cost from any money due the Contractor under this agreement; and may terminate the employment of the Contractor under this agreement, and take possession of the premises and of all materials, tools and appliances thereon, and employ such forces as may be necessary to finish the work. In such case the Contractor shall receive no further payment until the work shall be finished, when, if the unpaid balance that would be due under this contract exceeds the cost to the Company of finishing the work, such excess shall be paid to the Contractor; but if such cost exceeds such unpaid balance, the Contractor shall pay the difference to the Company.

In case of train haul of material, unless otherwise provided in this contract, the price for haul shall be computed at…………cents per cubic yard per mile. (This shall also apply to 33 (c).)

Company May Do Part of Work.

(c) Upon failure of the Contractor to comply with any notice given in accordance with the provisions hereof, the Company shall have the alternative right, instead of assuming charge of the entire work, to place additional forces, tools, equipment and materials on parts of the work for the purpose of carrying on such parts of the work, and the Contractor shall be allowed therefor the contract price. The Company may retain the amount of the cost of such work, with .... per cent. added, from any sum or sums due or to become due the Contractor under this agreement.

Annulment Without Fault of Contractor.

34. (a) The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving notice in writing to the Contractor, in which event the Contractor shall be entitled to the full amount of the estimate for the work done by him under the terms and conditions of this contract up to the time of such annulment, including the retained percentage. The Contractor shall be reimbursed by the Company for such expenditures as in the judgment of the Chief Engineer are not otherwise compensated for, and as are required in preparing for and moving to and from the work; the intent being that an equitable settlement shall be made with the Contractor.

Notice—How Served.

(b) Any notice to be given by the Company to the Contractor under this contract shall be deemed to be served if the same be delivered to the man in charge of any office used by the Contractor, or to his foreman or agent at or near the work, or deposited in the postoffice, postpaid, addressed to the Contractor at his last known place of business.

Removal of Equipment.

(c) In case of annulment of this contract before completion from any cause whatever, the Contractor, if notified to do so by the Company, shall promptly remove any part or all of his equipment and supplies from the property of the Company, failing which the Company shall have the right to move such equipment and supplies at the expense of the Contractor.

Failure to Make Payments.

35. Failure by the Company to make payments at the times provided in this agreement shall give the Contractor the right to suspend work until payment is made, or at his option, after thirty (30) days'

notice in writing, should the company continue to default, to terminate this contract and recover the price of all work done and materials provided and all damages sustained, and such failure to make payments at the times provided shall be a bar to any claim by the Company against the Contractor for delay in completion of the work, due to such suspension or failure to pay.

Monthly Estimate.

36. So long as the work herein contracted for is prosecuted in accordance with the provisions of this contract, and with such progress as may be satisfactory to the Chief Engineer, the said Chief Engineer will on or about the first day of each month make an approximate estimate of the proportionate value of the work done and of material furnished or delivered upon the Company's property at the site of the work, up to and including the last day of the previous month. The amount of said estimate, after deducting .... per cent. and all previous payments, shall be due and payable to the Contractor at the office of the Treasurer of the Company on or about the ....
.... day of the current month.

Acceptance.

37. The work shall be inspected for acceptance by the Company promptly upon receipt of notice in writing that the work is ready for such inspection.

Final Estimates.

38. Upon the completion and acceptance of the work, the Chief Engineer shall execute a certificate over his signature that the whole work provided for in this agreement has been completed and accepted by him under the terms and conditions thereof, whereupon the entire balance found to be due to the Contractor, including said retained percentage, shall be paid to the Contractor at the office of the Treasurer of the Company within .... days after the date of said final certificate. Before the time of payment of said final estimate the Contractor shall submit evidence satisfactory to the Chief Engineer that all payrolls, material bills, and outstanding indebtedness, in connection with this work, have been paid.

[8] FORM OF BOND.

KNOW ALL MEN BY THESE PRESENTS:

....

That the undersigned..

..........................are held and bound unto the...............

......................................in the sum of...............

........................dollars, lawful money of the United States of America (or Canada, as the case may be), to be paid to said........... its successors and assigns, to which payment the undersigned, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns.

The condition of this obligation is that if.........................

CONTRACTOR, shall faithfully furnish and do everything required in the contract, executed in writing, dated..............................19....

between..Contractor, and

.... Company

for ....

....

....

....

this obligation shall become of no effect; otherwise it shall continue in full force.

Signed, sealed and delivered this........day of..............19....

ATTEST:

....

....

---

[8] Adopted, Vol. 16, 1915, pp. 101, 1037.

[4] FORM OF INDUSTRY TRACK AGREEMENT.

THIS AGREEMENT, made this........day of........in the year....... by and between ....

....

....

party of the first part, hereinafter called the *Railway Company, and....

....

....

party of the second part, hereinafter called the Shipper:

WITNESSEH:

WHEREAS, the Shipper desires industry track facilities, hereinafter called sidetrack, for the more economical and convenient conduct of its his business, at or near................Station, County of.................., State of................, described as follows:

(Here describe length and exact location of track.)

in accordance with plans dated........................... (Note:—If desired insert "identified by the signature of..........................") hereto attached and hereby made a part hereof; and

WHEREAS, the operation of cars and engines over said sidetrack at other than the regularly established station facilities of the Railway Company involves the risk of damage to or destruction of property and injury to or death of persons;

Now, therefore, in consideration (Note:—If necessary insert one ($1) dollar, etc.) of the above premises, the covenants and agreements herein contained to be kept and performed by the parties hereto, and of the payments hereinafter to be made, it is mutually agreed that the said sidetrack shall be constructed and maintained, and the Railway Company hereby agrees to operate the same, under the following terms and conditions:

Right-of-Way.

1. The Shipper shall furnish at his its own expense all necessary right-of-way outside of the right-of-way of the Railway Company, required for the proper construction and operation of said sidetrack, said right-of-way to be satisfactory to the..................................of the Railway Company.

---

*Or "Railroad."

[4] Adopted, Vol. 19, 1918, pp. 352-357, 1176.

The cost and expense of procuring or complying with any ordinance, order, permit or consent whatsoever required by Municipal, State, or other lawfully constituted authorities for the construction, operation, maintenance and use of said sidetrack shall be borne by the Shipper.

During the continuance of this agreement the Railway Company shall have the right at all times to enter upon the property of the Shipper, for the purpose of constructing, maintaining and operating said sidetrack.

Construction.

2. The actual cost of constructing said sidetrack, including roadbed, trestles, bridges, and all other appurtenances in connection therewith, shall be borne as follows:

(Here insert details covering terms and conditions as to furnishing labor and material and division of expense as agreed upon.)

(Note.—If desired insert "The Shipper shall also assume the expense of recording this agreement.")

Maintenance.

3. Said sidetrack shall be maintained and renewed to the satisfaction of the....................of the Railway Company; the work shall be performed and the cost thereof borne as follows:

(Here insert details.)

Ownership.

4. The title and ownership of said sidetrack shall be vested as follows:

(Here insert details.)

Use.

5. The Railway Company shall have the right to use, without cost, the whole or any part of said sidetrack for general railroad purposes, provided such use shall not unreasonably interfere with the use thereof by the Shipper.

The Shipper agrees that he/it will not permit or authorize the use of said sidetrack by or for the benefit of any other person, firm or corporation not one of the parties hereto, nor assign this contract or any rights thereunder, without the written consent of the Railway Company.

Changes or Enlargement.

6. If any change, rearrangement, extension or enlargement of said sidetrack or its structures shall at any time be required by reason of any change in the Railway Company's track or tracks, or because of any changes in the operating practice of the Railway, or for any other cause, all expense resulting therefrom shall be borne by the Shipper, unless otherwise mutually agreed by the parties hereto.

Clearances.

7. The Shipper shall not erect nor permit to be erected any building or structure, nor permit any material to be placed above top of rail within.............. (......) feet of the nearest rail of said sidetrack on straight track, or within.......... (......) feet on curve, nor permit anything to be placed above said sidetrack lower than a height of........ (......) feet above the top of rail.

Accidents.

8. The Shipper agrees to exercise the greatest care in the use of said sidetrack to prevent cars or other obstructions from getting upon or too close to main or other tracks and generally to use such means and care as will avoid accidents of every kind.

Liability.

9. The Shipper hereby agrees to indemnify, protect, and save harmless the Railway Company for loss of, damage to, or destruction of $\substack{\text{it}\\\text{his}}$ property, or the property of any other person or persons upon the premises of the Shipper by $\substack{\text{its}\\\text{his}}$ request or consent, whether by fire or otherwise, or of death or injury to any person or persons (except where it can be shown that such death or injury to person or persons was due solely to negligence on the part of employees of the Railway Company) arising out of the construction, maintenance, use or operation of said sidetrack.

Discontinuance.

10. The Shipper shall assume and bear any and all loss or damage sustained by $\substack{\text{him}\\\text{it}}$ in consequence of any temporary or permanent elimination of said sidetrack, due to the relocation or change in the grade of the track or tracks of the Railway Company by virtue of any municipal action or otherwise, or in event the disposition of the property of the Railway Company or its future use or development shall make it impracticable in the judgment of the............of the Railway Company to continue the connection, and the Shipper hereby waives any and all claims therefor.

Cancellation, Termination and Removal.

11. It is expressly understood and agreed that if for the space of........consecutive months said plant be not operated, unless prevented by a strike or strikes, or if the title to said plant become vested in or the operation thereof be transferred to some party other than the Shipper, or if any other party operating said plant refuses to adopt this agreement and to agree in writing to be bound thereby, or if the Shipper fails to keep and perform any of the covenants, agreements, terms, or conditions, hereinbefore set forth to be by him it kept and performed, then the Railway Company reserves the right to terminate this agreement upon.......... days' written notice to the Shipper.

Upon termination of this agreement the Railway Company shall have the right to enter upon the property of the Shipper and take up and remove any or all of the material owned by the Railway Company as aforesaid, and shall not be liable to account in any way to anyone for any monies paid or expended on account of any of the track or tracks covered by this agreement, nor for any damages resulting from the removal of the track or tracks owned by the Railway Company as aforesaid.

Until terminated as hereinbefore provided, this agreement shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

In witness whereof, the parties hereto have executed this agreement in........ the day and year first above written.

........................Railway Company
By............................

Witness for Railway Company.

....

(Shipper)..............................
By............................

Witness for Shipper.

....

RECOMMENDATION.

BASIS FOR DIVISION OF COST OF CONSTRUCTION AND MAINTENANCE, AND OWNERSHIP OF INDUSTRY TRACKS.

After leaving the right-of-way of the Railway Company, all responsibilities of the Company as a common carrier cease and in going beyond the right-of-way, the Railway Company becomes the Agent of the Shipper in the operation of said sidetrack, thereby contributing to the economical operation and efficiency of its plant. This fundamental principle should, therefore, be considered in determining the basis for dividing the cost of construction and maintenance, and the ownership of such industry track.

An industrial sidetrack is essentially a plant facility and furnishes the shipper with service elsewhere than at the regular station of the Railway Company. It is, therefore, recommended, as a matter of equity, in constructing such track, that the following terms as to division of expense and the ownership of property, should govern:

(1) The Railway Company may pay for and shall maintain that portion of the sidetrack from the switch point to the clearance point.

(2) The Shipper shall pay for and maintain that portion of the sidetrack beyond the clearance point, including roadbed, trestles, bridges and all other appurtenances.

(3) That portion of the sidetrack upon the right-of-way of the Railway Company shall be and remain the property of the Railway Company.

(4) That portion of the sidetrack beyond the right-of-way of the Railway Company shall be and remain the property of the Shipper.

[5] FORM OF AGREEMENT FOR INTERLOCKING PLANT.

This Agreement, made this............day of.............., 19..
by and between ....
hereinafter called the..................................Company
and ....
hereinafter called the..................................Company

Witnesseth that:

Whereas, (Note.—Include brief description of conditions, including the location of existing or proposed grade crossing; an enumeration of all existing agreements, if any; the names of the companies between which agreements were made, their dates, purpose, etc.)

Whereas, the parties hereto mutually desire to construct, maintain, renew and operate an interlocking plant at said crossing, the location of said crossing being shown, and the said interlocking plant to be arranged as shown on the blue print marked Exhibit A, dated.................... ...., identified by the signatures of the........................of the......................Company, and of the......................of the........................Company, hereto attached, and hereby made a part of this agreement.

---

[5] Adopted, Vol. 19, 1918, pp. 358-365, 1177.

Now, THEREFORE, in consideration of the premises and of the mutual conditions and agreements hereinafter set forth, the parties hereto do covenant and agree as follows:

Definition.

1. The term Interlocking Plant, herein contained, shall be held and taken to include any and all houses, towers, power plants, machinery, appliances and appurtenances required for the operation of the same.

Construction.

2. The................Company agrees to construct an interlocking plant, as shown on said Exhibit A, and in accordance with specifications which have been approved by the........... of the parties hereto, and identified by their signatures.

The cost of removing any existing safety appliances or devices shall be divided in like manner as the maintenance and renewal expense of said appliances or devices has heretofore been divided.

The................Company agrees to begin the construction of said interlocking plant within..........days after the execution of this agreement, and to carry the same forward to a prompt completion.

(Note.—Insert penalty clause if desired.)

Apportionment of Cost.

3. (a) The cost of constructing, maintaining and renewing said interlocking plant, as shown on said Exhibit A, shall be borne by the parties hereto as follows:

Each party hereto shall participate in the ownership of said interlocking plant in the ratio which the payments made by it for construction of said interlocking plant, including extensions and changes chargeable to capital account, bear to the total cost of construction thereof.

The expense of maintaining and renewing said interlocking plant shall include taxes, assessments and insurance; all losses by fire, flood or other damage caused by the elements; also any change made necessary by an act, law, or ordinance, of a lawfully constituted public authority.

(b) The cost of operating said interlocking plant, including power, heat, light, and supplies, shall be borne by the parties hereto as follows:

Spare Space.

4. Spare levers, machine spaces, and building space, may be provided for its exclusive use upon request of either of the parties hereto, at the sole cost and expense of such party; provided further, that the other party to this agreement may hereafter acquire the right to the exclusive use of the same by either paying the original cost, or by providing an equal amount of space of the kind used when the same shall be required, at the election of the party which originally provided the spare space.

Extensions and Changes.

5. Either party shall have the right to make extensions or changes in said interlocking plant, provided that they shall not materially impair the efficiency of the same. All such extensions or changes, arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections, which either party hereto may have the right to construct, or which may be required by reason of any changes made in the standard appliances of either party, or which may be ordered by a lawfully constituted public authority, shall be made by the.......... Company, and the cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the amount chargeable to each party for maintenance, renewal and operation in such case shall be determined as follows:

Control of Plant.

6. Maintenance.—(a) The maintenance and renewal of said interlocking plant shall be under the sole charge and control of the........... Company, and it shall employ competent persons to maintain and renew the same, and such parties from time to time so employed shall be removed for good and sufficient reason upon request in writing of a general managing officer of the.............. Company.

Each of the parties hereto, through its authorized employees and representatives, shall have the right at all times to inspect said interlocking plant, as well as the accounts covering the construction, maintenance, renewal and operation of the same; and in the event that the ....

Company shall notify the .... Company in writing of renewals and repairs that may be necessary for the safe and proper operation of said interlocking plant, and if the .... Company neglects for a period of thirty days to make said necessary renewals and repairs, then the .... Company shall have the right to make such renewals and repairs, and the .... Company shall, upon presentation of proper bills, and within the time provided in Section 10 hereof, pay its proportion of the amount so expended.

(b) Each of the parties hereto shall, at its own expense, keep all switches and derails in its own tracks free from ice, snow, dirt or other obstructions which may interfere in any way with the proper working of said interlocking plant; and in case either party fails to do so, the other party may enter upon the premises of the party at fault and remove such ice, snow, dirt or other obstructions; in which event, the party at fault shall reimburse the party doing such work, as provided in Section 10 hereof, for all expense thereby incurred.

OPERATION.—(c) The operation of said interlocking plant shall be under the sole charge and control of the .... Company, and it shall employ competent persons to operate the same, and such persons from time to time so employed shall be removed for good and sufficient reasons upon request in writing of a general managing officer of the .... Company.

It is further mutually understood that either party may use the operators at said interlocking plant in its telegraph or telephone service, provided said party shall give the other party at least ten days' prior written notice of the same; but in the event that additional expense is so incurred, either on account of increased wages of operators over levermen, or on account of additional employees required, the party using the operators in its service shall bear the additional expense. If for any reason it becomes necessary to temporarily take the said interlocking plant out of service, the control of the flagmen required to protect said grade crossing shall also be in the .... Company, and the expense of said flagmen shall be considered, for the purpose of apportionment, as an expense of operating said interlocking plant.

Material and Labor Supplied by Parties.

7. Each of the parties hereto shall, without cost to the other, furnish and install its own derails, switch points, switch rods, special switch and derail ties and timbers, all track insulations, poles, cross-arms, pins and insulators, and will maintain and renew them from time to time there-

after; likewise, without cost to the other party, do all the track work and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and also provide and maintain proper drainage; likewise, bear the cost and expense of raising and adjusting pipe carrier and mechanism foundations, or the renewal of detector bars, clips or any other appliances required or made necessary by the resurfacing, reballasting or rail renewal of its tracks within the limits of said interlocking plant; likewise, furnish and install at its own expense any signal bridges, or other special signal supports, which may be required to support signals governing the movement of trains on its tracks.

Either party shall have the right to carry its automatic block signaling through the limits of the interlocking plant at its own expense. Where signals perform the function of both block and interlocking signals, the party hereto whose train movements are controlled by said block signals shall maintain the same at its expense.

Precedence.

8. In the use of said interlocking plant, passenger, mail and express trains shall have precedence over freight trains and light engines; and freight trains shall have precedence over light engines. The trains and engines of the .... Company shall have precedence over the trains and engines of like class of the .... Company.

Payment of Bills.

9. All payments hereunder shall be made within thirty days after rendition of proper bills.

The .... Company shall render bills covering the cost of constructing said interlocking plant, such expense to be billed in one statement unless otherwise agreed upon by the parties hereto.

Bills covering the operation, maintenance and renewal of said interlocking plant shall be rendered monthly; and those covering insurance, taxes and assessments, annually.

Such of said bills as are based upon payroll cost of labor and stock prices of material shall include a fair arbitrary charge to cover supervision, inspection, handling, transportation, accounting and similar undistributed items of expense. Such fair arbitrary charge shall be in accordance with the recommendations of the General Managers' Association of ...., in effect from time to time, or in the absence of any such recommendations, shall be agreed to by the parties, or determined by arbitration as hereinafter provided.

Should dispute arise as to the correctness of any items included in bills rendered under this agreement, the party against which such bills are rendered shall pay all items concerning which there is no dispute, and the other items shall be paid promptly when the correctness thereof has been ascertained by arbitration or otherwise.

Liability.

10. Each party hereto assumes for itself the responsibility and risk of using and operating its own trains and engines over the space covered by the said interlocking system, and also responsibility for the negligent acts and omissions or the alleged negligent acts or omissions of its own officers, agents, servants and employees engaged in connection therewith; and in performance of any of its separate duties under this contract; and will pay to the other party and to third persons all damages which may arise and for which it may be liable arising from such negligence and in such operation.

The party having special charge of the management and operation of said interlocking system shall not be liable to the other party for the negligent acts or omissions, or the alleged negligent acts or omissions of any person employed in the operation, maintenance or repair of said interlocking mechanism, but all persons so employed shall, as respects any injury caused by such negligence, be regarded and treated as the agents or servants of each party hereto, and each of said parties hereby assumes the responsibility for all damages resulting from the negligence of such agents or servants in the operation of its own engines, cars and trains, and those of its tenants, lessees and licensees, at the said crossings, and shall indemnify and save the other party harmless therefrom. Any expense caused or growing out of the injury of any workman or employee engaged upon the construction of said interlocking plant shall be held and considered to be a construction expense, and shall be divided as herein in Section 3 provided.

Arbitration.

11. In case of any differences or dispute arising under this agreement or concerning the subject-matter thereof, the parties hereto agree to submit such difference or dispute to three arbitrators, one of whom shall be appointed by the .... Company, and another by the .... Company, and each party shall give to the other party written notice of appointment of its arbitrator, together with his name and address. The two arbitrators so chosen shall select a third arbitrator. If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expira-

tion of .... days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within .... days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include ...., or

....

who shall thereupon appoint the third arbitrator. The three arbitrators so chosen in any manner as herein provided, or a majority of them, shall hear and decide said difference or dispute, and their decision, or that of a majority of them, shall be final and binding on the parties hereto.

The expense of an arbitration under the terms hereof shall be borne by the parties hereto in the proportions fixed by the arbitrators.

Cancellation of Conflicting Agreements.

12. It is mutually understood and agreed that any and all agreements existing between the parties hereto or their predecessors, so far as they conflict, or are inconsistent with the terms and conditions of this agreement, are hereby annulled, but in all other respects they shall continue in full force and effect.

Duration and Succession.

13. This agreement shall take effect on the..................day of ...., 19...., and shall continue in force during the existence and operation of the interlocking plant, or until discontinued by the mutual agreement of the parties hereto.

The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

In Witness Whereof, the parties hereto have caused this agreement to be executed in duplicate, by their respective officers, thereunto duly authorized, the day and year first above written.

....Company,

Secretary. By...

....Company,

Secretary. By...

[6] FORM OF AGREEMENT FOR CROSSING OF RAILWAYS AT GRADE.

THIS AGREEMENT, made this..............day of..................
in the year................, by and between..........................,
party of the first part, hereinafter called...............................,
and..., party of the second
part, hereinafter called..

Historical.

WHEREAS, ...
....
....
....

(Note.—Include brief description of conditions, including the location of existing or proposed grade crossing, an enumeration of all existing agreements, if any, the name of the companies between which agreements are made, their dates, their purpose, et cetera.)

WHEREAS, ... desires the right to construct, maintain, use and operate a railway crossing at grade across the tracks and right-of-way of.......................to permit the passage of its trains over and across the right-of-way and tracks of...........
..........................and.........................is willing to grant said right; the location of said crossing and its proposed arrangement being shown upon a blueprint marked "Exhibit A," dated..........
.................................., identified by the signature of the
.... of ....
and of................................. of ....
hereto attached and hereby made a part of this agreement; and

WHEREAS, The parties hereto have agreed upon the terms and conditions upon which said crossing as shown upon said Exhibit A shall be constructed, maintained and operated.

NOW, THEREFORE, in consideration of the premises and in further consideration of the mutual covenants and agreements hereinafter stipulated to be kept and performed, it is mutually agreed between the parties hereto, for the purpose of defining the terms and conditions upon which said crossing shall be constructed, maintained, renewed and operated, as follows:

Definition.

1. The term crossing as herein contained shall include rail, crossing frogs, track fastenings, crossing timbers, and other track appliances, in-

---

[6] Adopted, Vol. 20, 1919, pp. 217, 914.

cluded between the outer joints of one or more crossings installed or hereafter installed; together with ballast, drainage, side ditches, subdrainage, and other substructure appliances, devices or supports on the right-of-way of.................................... Company in so far as affected by said crossing; all necessary buildings, including flagmen's houses, shanties or towers; gates, semaphores and other safety devices or appliances; all as may be required to keep said crossing in safe and suitable condition for the operation of trains, as required by............. ....Company or by lawfully constituted public authority.

Grant.

2. .... hereby grants to..................... subject to the conditions and stipulations of this agreement, the right to construct, maintain, renew and operate at grade.........., track.......... of the...................................... Railway, over and across the right-of-way and tracks of.. at the point of crossing, as shown on "Exhibit A."

Construction.

3. The.................................Company agrees to construct a railway crossing at grade as shown upon said "Exhibit A" and according to detail plans and specifications, which have been approved by the....................................Engineer of the................ ....and identified by..........................signature. The said..Company agrees to begin the construction of said crossing within................ days after the execution of this agreement and to carry the same forward continuously to prompt completion.

Apportionment of Cost.

4. The cost of constructing, maintaining, renewing and operating said crossing shall be borne by the respective parties hereto as follows:

....

....

....

In the cost of maintaining and renewing said crossing shall be included the expense for taxes, assessments, and insurance; any losses by fire, floods and other damage caused by the elements; also any change made necessary by an act or ordinance of a lawfully constituted public authority, except as herein otherwise provided.

Extensions and Changes.

5. (a) The....................................Company reserves the right to construct, maintain, renew and operate upon its right-of-way from time to time such other additional track or tracks as it may deem necessary or desirable crossing the track or tracks of the...Company, the right to construct which is herein granted, and all the provisions and stipulations herein contained shall apply to such other additional track or tracks.

(b) The....................................Company reserves the right to change the grade of its track or tracks as shown on said "Exhibit A" not to exceed...............feet, and the grade of the crossing shall be changed to conform thereto. The expense of so changing shall be borne as follows:

....

....

....

(c) Either company shall have the right at its own expense to make minor changes in alinement at said crossing, provided that this shall not materially interfere with the tracks of the other party, but nothing herein contained shall be interpreted to cover major changes in grade or alinement, such as separation of grade or elevation of tracks required or brought about by laws or ordinances of properly constituted public authorities.

(d) Improvements or devices which may be necessary in order to conform to the standard practice of the.........................Company shall be provided as required by that Company, and the expense shall be borne in accordance with the provisions of Section 4 hereof.

(e) The privileges hereinbefore granted are granted upon the further express condition that whenever anything may be done or may be required to be done by the Chief Engineer of.........................Company, or under and in pursuance of any of the laws of the State of...................................., or of any lawful action of proper public authorities in respect to the said crossing, including the installation of gates, signals or interlocking, the...............................Company shall make all changes at said crossing and in present or future tracks of both companies and their appliances, necessary to comply with or carry out the requirements of the Chief Engineer of the.......................................Company or of law, or action of such authorities, and the cost thereof shall be apportioned in accordance with Section 4 hereof.

(f) It is further understood and agreed that the..Company will pay the cost of any connecting or transfer track or tracks that may, at any time, be required at or near the point of the crossing aforesaid, whether such track or tracks be ordered by competent authority, or put in by agreement between the parties hereto. If the junction switches of the said connecting track or tracks in the main track or tracks of either of the parties hereto shall be or come to be within the limits of an existing interlocking plant, said junction switches shall be taken into the protection of said interlocking plant and the cost shall be borne as follows:

....

....

....

Maintenance and Renewal.

6. The crossing shall be maintained by the..........................Company. In case..Company shall remove its tracks or any of them at said crossing, the track or tracks of the..Company shall be restored by the..................................Company to their original condition, to the satisfaction of the Chief Engineer of the.. Company, and at the sole cost and expense of the...Company.

Control.

7. The maintenance, renewal, operation and protection of said crossing shall be under the sole charge and control of the...Company, and it shall employ competent persons to maintain, renew and protect the same, and such parties from time to time so employed shall be removed for good and sufficient reason upon request in writing of a general managing officer of the...Company.

Each of the parties hereto, through its authorized employees and representatives, shall have the right at all times to inspect said crossing, as well as the accounts covering the construction, maintenance, renewal and operation of the same; and in the event that the..................Company shall notify the...................................Company in writing of renewals and repairs that may be necessary for the safe and proper operation of said crossing, and if the...........................Company neglects for a period of thirty days to make said necessary renewals and repairs, then the...................................Company shall have the right to make such renewals and repairs, and the.......... ....Company shall, upon presentation of proper bills, and within the time provided in Section 11 hereof, pay its proportion of the amount so expended.

Protection.

8. During construction and thereafter, flagmen or signalmen shall be furnished for the proper protection of said crossing, and such persons from time to time so employed shall be removed for good and sufficient reasons, upon request in writing of a general managing officer of the ....Company. The expense for their wages together with the cost of materials and supplies required in connection with their work, shall be apportioned as herein in Section 4 provided. Until interlocking protection shall have been provided, all trains shall approach said crossing under full control, and shall come to a full stop within............feet from said crossing, and shall not proceed until the receipt of a proper signal so to do.

9. The............Company reserves the right, so long as it maintains fence up to the point of intersection of the..............Company's track with the respective boundary lines of the..............Company's premises, to require the............ Company to build and maintain in good order, proper stock-guards at the point of intersection aforesaid, for the purpose of preventing trespass upon said Company's premises from the track or grounds of said .... Company.

10. If the .... Company shall (during the life of this contract) electrify its railroad at the said crossing, upon .... days' written notice to the .... Company, the said .... Company agrees to furnish, maintain and install such electric appliances, fixtures and appurtenances at said point of crossing as may be necessary for the safe and convenient operation of said crossing, and to the satisfaction of the Company's Engineer.

Precedence.

11. In the use of said crossing, passenger, mail and express trains shall have precedence over freight or work trains and light engines, and freight or work trains shall have precedence over light engines. The trains and engines of the...........................Company shall have precedence over the trains and engines of like class of the............. Company.

Ownership.

12. Each of the respective parties hereto shall participate in the

ownership of the crossing in the proportion which the payments made by it for construction of same bear to the total cost of construction.

Payment of Bills.

13. The payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. The bills for expense of construction shall be made as a final bill, unless otherwise mutually agreed and understood.

Bills covering maintenance, renewals and operation, taxes and assessments shall show total expenditures, and proportions chargeable to each of the respective parties hereto, and shall be rendered monthly; those covering insurance, taxes and assessments annually.

Should any dispute arise as to the correctness of any of the items included in bills rendered, under this agreement, the party against which any such bill is rendered shall pay as herein provided an amount equal to the sum of all items in said bill, the correctness of which is unquestioned. The remainder, covering disputed items, shall be paid promptly as herein provided, upon an adjustment of the dispute.

Added Percentages.

14. In making bills for the cost and expense of constructing, renewing, maintaining, operating and protecting said crossing, all labor and material shall be charged for at actual cost, plus............per cent. added to material, and................per cent. to labor to cover freight charges or accruals, handling, superintendence, use of tools and accounting, except that work done by contract shall have no percentages added.

Such of said bills as are based upon payroll cost of labor and stock prices of material shall include a fair arbitrary charge to cover supervision, inspection, handling, transportation, accounting and similar undistributed items of expense. Such fair arbitrary charge shall be agreed to by the parties, or determined by arbitration as hereinafter provided.

The provision as to actual cost herein contained shall not be considered or held as a warrant for charging excessive prices or freight rates on material, for hauling the same unreasonable distances, nor for the payment of unreasonable arbitrary charges of any kind.

Liability.

15. Each party hereto assumes for itself the responsibility and risk of using and operating its own trains and engines over the space covered by the said crossing, and also responsibility for the negligent acts and omissions or the alleged negligent acts or omissions of its own officers, agents, servants and employees engaged in connection therewith; and in

performance of any of its separate duties under this contract; and will pay to the other party and to third persons all damages which may arise and for which it may be liable arising from such negligence and in such operation.

The party having special charge of the management and operation of said crossing shall not be liable to the other party for the negligent acts or the omissions, or the alleged negligent acts or omissions of any person employed in the operation, maintenance or repair of said crossing, but all persons so employed shall, as respects any injury caused by such negligence, be regarded and treated as the agents or servants of each party hereto, and each of said parties hereby assumes the responsibility for all damages resulting from the negligence of such agents or servants in the operation of its own engines, cars and trains, and those of its tenants, lessees and licensees, at the said crossing, and shall indemnify and save each of the other parties harmless therefrom. Any expense caused or growing out of the injury of any workman or employee engaged upon the construction of said crossing shall be held and considered to be a construction expense, and shall be divided as herein in Section 4 provided.

Arbitration.

16. In case of any difference or dispute arising under this agreement or concerning the subject-matter thereof, the parties hereto agree to submit such difference or dispute to three arbitrators, one of whom shall be appointed by the......................Company, and another by the ....Company, and each party shall give to the other party written notice of appointment of its arbitrator, together with his name and address. The two arbitrators so chosen shall select a third arbitrator. If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expiration of........days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within..............days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include...

....

or who shall thereupon appoint the third arbitrator. The three arbitrators so chosen in any manner as herein provided, or a majority of them, shall hear and decide said difference or dispute, and their decision, or that of a majority of them, shall be final and binding on the parties hereto.

The expense of an arbitration under the terms hereof shall be borne by the parties hereto in the proportions fixed by the arbitrators.

Cancellation of Conflicting Agreements.

17. It is mutually understood and agreed that any and all agreements relative to said crossing, existing between the parties hereto or their predecessors, so far as they conflict, or are inconsistent with the terms and provisions of this agreement, are hereby annulled, but in all other respects they shall continue in full force and effect.

Duration and Succession.

18. This agreement shall remain in full force and effect as long as the tracks of the respective parties cross at grade at the location shown upon "Exhibit A."

The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

In Witness Whereof, the parties have caused these presents to be executed in duplicate by their respective officers as of the day and year first above written.

Attest:

....	............................Company
Secretary	By..................................
	....

Attest:

....	............................Company
Secretary	By..................................
	....

FORM OF LEASE AGREEMENT FOR INDUSTRIAL SITE.[7]

Parties.

1. This Lease, Made in....................this.................day of...............19....., by and between the........................ ...., a corporation, the Lessor, hereinafter called the Company, and.. having a principal office or place of business in......................... in the...................and.................., hereinafter called the Lessee,

---

[7] Adopted, Vol. 22, 1921, pp. 256, 995.

WITNESSETH:

That the Company in consideration of the agreement of the Lessee herein contained, hereby leases unto the Lessee, all those certain premises, situated in........................, County of........................, State of...................., described as follows:

Description.

2. .... the location and dimensions of said premises being more definitely shown on the plan hereto attached, designated as...and dated.. and hereby made a part hereof.

Term.

3. To have and to hold the same from.............................. 19...., to..........................19...., unless sooner terminated, as hereinafter provided.

Termination.

4. Either party hereto may terminate this lease at any time, by giving to the other party.......................days' written notice to that effect. Acceptance of rent in advance by the Company shall not act as a waiver of the right to terminate this lease.

Notice.

5. Any notice given by the Company to the Lessee shall be deemed to be properly served if the same be delivered to the Lessee, or if left with any of......................agents, or if posted on said premises, or if deposited in the postoffice, postpaid, addressed to the Lessee at.......... .... last known place of business.

Rent.

6. The Lessee shall pay a rental of.............................. per...................., payable............................in advance, beginning on.............................., for the use of said premises, payable to the..................of the Company, at....................

Refund.

7. Rent paid in advance for a period extending beyond the termination of this lease shall be repaid to the Lessee within thirty days

after demand, unless such termination shall be on account of violation or non-fulfillment of any of the terms of this lease by the Lessee, or on account of abandonment of said premises by the Lessee, in which case the amount paid as rental shall be retained by the Company.

Taxes.

8. The Lessee shall pay all taxes, licenses and other charges which may be assessed or levied upon said premises, improvements thereon, and upon the business of the Lessee upon said premises, or against the Company by reason of occupation or use of said premises by the Lessee.

Purpose.

9. The said premises shall be used for the following purposes:
....
....

Assignment.

10. This lease shall not be assigned or in any manner transferred nor said premises or any part thereof sub-let, used or occupied by any party other than the Lessee, nor for any purpose other than that specified herein, without the written consent of the Company.

Abandonment.

11. The failure of the Lessee to occupy or use said premises for the purpose herein mentioned for..................days at any one time shall be deemed an abandonment thereof. An abandonment of said premises by the Lessee, shall operate as an absolute and immediate termination of this lease without notice.

Improvement.

12. The Company hereby gives to the Lessee, subject to all of the conditions hereof, the privilege of erecting, maintaining and using on said premises, suitable buildings and other structures for the aforesaid purposes; provided that such buildings and other structures shall be first approved by .... of the Company, and thereafter maintained as to meet with the approval of the........................ of the Company; that the Lessee shall, so long as this lease continues, keep all buildings and other structures on said premises in good repair, including painting, so as to present a good appearance, so far as required by such .... and that the Lessee shall install, rearrange and maintain such improvements as may reasonably be required by said Company for the reduction of fire hazard.

Clearance.

13. The Lessee shall neither erect nor place, nor permit to be

erected or placed, upon said premises any structures or obstruction that will in any way imperil the safety of trains, engines or cars upon such railroad tracks as are now or may hereafter be located on, or adjacent to said premises, or the safety of persons or property in, upon, or about such trains, engines, cars or tracks. The minimum horizontal and vertical clearances from the tracks shall be prescribed by................. of the Company upon request.

Removal of Improvements.

14. Upon the termination of this lease in any manner, the Lessee, upon demand of the Company, without further notice, shall deliver up to the Company the possession of said premises, and shall if required, remove all the improvements placed thereon by the Lessee, and restore said premises to substantially their former state, and in case the Lessee shall fail, within..............days after the date of termination of this lease, to make such removal or restoration, then the Company may, at its election, either remove said improvements and restore said premises for the account and at the sole cost of the Lessee, or may take and hold the said improvements as its sole property.

Inflammables.

15. No goods of an explosive, dangerous or inflammable nature or character shall, in any case, be stored in or upon said premises without the written consent of the Company.

Condition of Premises.

16. The Lessee shall at all times keep said premises and the vicinity thereof, in a safe, clean and sanitary condition. The Lessee shall not mutilate, damage, misuse, alter or commit or suffer waste in premises.

Advertising.

17. No advertising shall be placed upon said premises or upon any structures thereon, except for the Lessee's own legitimate purposes, and all advertising so placed shall be to the satisfaction of the.......... ....of the Company.

Laws and Regulations.

18. The Lessee shall in all respects abide by and comply with all laws, rules, regulations and ordinances affecting the said premises.

Miscellaneous Charges.

19. The Lessee shall pay all charges for water and lighting and for street or road sprinkling, sweeping or oiling, that may be levied or assessed against said premises, covering the period of occupancy.

Snow and Ice.

20. The Lessee shall at all times keep the sidewalks in front of said premises free and clear of snow and ice, and any expense to the Company by reason of the failure of the Lessee so to do shall be paid by the Lessee to the Company upon demand therefor; such expense to include all loss or damage of whatsoever character, either to persons or property.

Use of Tracks.

21. The Lessee shall not permit nor allow tracks belonging to others than the Company to be constructed upon said premises, and the Lessee will not permit nor allow trains or engines belonging to others than the Company to be used upon or given access to said premises, without the written consent of the Company.

Company's Right of Entry.

22. The Company shall have the right at all times to enter upon and to construct railroad tracks on said leased premises, and to maintain and operate, and to extend or change the location at any time, of such tracks as are then on said premises, upon................days' written notice to the Lessee. If any structure on said premises shall obstruct or interfere with the construction of additional main or passing tracks of the Company, or if required for proper clearance of tracks, the Lessee at .... expense, shall promptly move such structure to another location, either on or beyond said premises as may be necessary, upon .... days' written notice to the Lessee.

Access to Premises.

23. In the event it is necessary for the Lessee or his agents, servants, workmen and customers to pass over other lands of the Company and railway tracks of the Company, to have access to and from said premises, all such persons shall make use only of the way indicated by the ...., of the Company for that purpose, and the Lessee hereby expressly assumes all the risk of accident and injury to the person and property of all such agents, servants and workmen, and all others resorting to the leased premises in connection with the Lessee's business, whether the same be occasioned by the negligence of the Company's servants or in any other manner whatever, and the Lessee shall indemnify the Company from and against all claims, suits, costs and charges made upon or incurred by the Company by reason or in consequence of any such accident, loss and injury.

Liability.

24. (a) The Lessee assumes all responsibility for and agrees to indemnify the Company against loss or damage to property of the Lessee or of others upon said premises, regardless of negligence of the Company, arising from fire caused by locomotives operated by the Company in serving the Lessee upon said premises, or in the vicinity thereof, except to rolling stock belonging to the Company or to others, and to shipments in the course of transportation.

(b) The Lessee agrees to indemnify, protect and save harmless the Company for loss of, damage to, or destruction of property of the Lessee or of others upon said premises whether caused by fire or otherwise (except fire caused by locomotives as hereinbefore provided for), or for death of or injury to, any person or persons, arising out of the construction, maintenance, use, or operation on said premises (except where such death or injury was due solely to negligence of the Company).

Forfeiture.

25. Any breach of any covenant, stipulation or condition herein contained to be kept and performed by the Lessee, shall after............ days' written notice, if continued, at once terminate this lease, and all rights of the Lessee hereunder. No further notice of such termination or declaration of forfeiture shall be required, and the Company may at once re-enter upon said premises and repossess itself thereof, and remove all persons therefrom, or may resort to an action of forcible entry and detainer, or any other action to recover the same.

Right of Inspection.

26. The said premises shall be open at all reasonable times to the inspection of the Company, its agents, and applicants for purchase or lease.

Renewal.

27. If the Lessee, with the consent of the Company, holds over and remains in possession of said premises after the expiration of said term, this lease shall be considered as extended, and shall continue in effect from, ..., to .... subject, however, to termination as herein provided, and upon the same terms and conditions as are herein contained. Until terminated as hereinbefore provided, this lease shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

In Witness Whereof, the parties hereto have executed this lease on the day and year first above written.

....

Company.

....

....

Witness:..

Witness:..

By..

INDEX

INDEX

A PAGE
Agreement forms—
—grade crossings 979
—industry track 968
—interlocking plant 972
—lease for industrial site 986
Anti-creepers, general requirements 212
—application of 600
Approach warning sign 458
Ashpits 240
Aspects, signal 473
Authority for expenditure form 513
—register of 517

B
Bad-order cars, transfer of lading of 693
Ballast—
—choice of 70
—cleaning foul 93
—comparative merit of material for 70
—deck trestles, comparative merits 295
—definitions 69
—forks 91
—organization and distribution of gang 87
—proper depth of 79
—reinforcement under 94
—report form 502
—sections 82
—specifications for burnt clay 78
——cinder 79
——gravel 75
——pit run gravel 77
——stone 71
——tools 93
——washed gravel 75
Ballasting by contract 94
—on an operated line 83
—track 601
Bars, joint, specifications for..128, 137
—tamping 90
Bermuda grass, specifications for sodding with 62
Bond, form of 967
Boilers, care of, examination questions 648
Borrow pits 28
Brick masonry, definitions 371
Bridges—
—classification for operating purposes 790
—contracting for 737
—definitions 281
—erection, inspection of 730
Bridges—Continued. PAGE
——specifications 737
—general specifications for steel railway 742
—monthly estimate form 504
—protection of traffic at movable. 733
—rules and unit stresses for rating existing 787
——inspection 610
—sign 462
—specifications for metal details.. 293
Bronze bearing metals for turntables 735
Buildings—
—definitions 239
—engine house design 243
—freight houses 247
—locomotive coaling stations 256
—oil houses 257
—passenger stations 258
—rest houses for employees 265
—section tool houses 279

C
Carbon steel rails, specifications for 115
Cement, specifications for Portland and Natural 375
Chart, track 530
Cinder ballast 79
Classification, definition 17
—for cypress lumber and shingles. 354
—for hemlock lumber 360
—lumber and timber 303
—of bridges for operating purposes 790
—of track 16
—of the uses of lumber 364
Clay ballast, burnt, specifications. 78
Clearance lines for equipment and permanent way structures 855
—for bridges 744
—for tunnels 58
Clearing, specifications 23
Coaling stations, locomotive 256
Coal tar in creosote, use of 822
Column formula 732
—tests 732
Concrete—
—designs of reinforced structures. 420
—disintegration of 434
—fence posts 449
—piles, specification for constructing 415
—plain and reinforced, specification 400
—masonry, definition 373

Concrete—Continued. Page
—methods for depositing under water 423
—repairing, method of 435
Conduit construction, underground, specifications 932
Construction contract form 955
—agreement form 979
Contract and lease record 528
—ballasting by 94
—construction form 955
—definition 17
—requirements, general 21
Conventional signs 541
Cranes, locomotive 35
Creosote—
—coal-tar solution, precautions to be followed in the purchase and use of 822
—coal-tar solution, specifications for 821
—oil analyses, specifications for 823
—oil and creosote coal-tar solution 844
—oil, specifications for Grade 1 819
—oil, specifications for Grade 2 820
—oil, specifications for Grade 3 821
—water in 844
Crossings, specifications 214
—agreement form 979
—road 606
—sign, wooden 455, 456
Crossover, definition 155
Cross-ties, specification 97
—of different materials, economic comparison 107
—records 106
Culverts, rules for inspection 610
Curvature 817
Curve resistance, freight cars 817
Curves of conductor sags 877
—economy, for structures of various ratios of life periods 301
—speed of trains through 188
—use of easement 157
Cut list for handling cars 691
—track spike, design of 199
—track spikes, specifications for 197
Cuts, drainage of large 68
—slopes of 67
Cypress lumber, grading rules 354

D

Dating nails, specifications 105
—use of 105
Deep wells, record of 680
Definitions—
—ballast 69
—buildings 239
—economics railway location 800
—electricity 853

Definitions—Continued. Page
—masonry 369
—records and accounts 499
—roadway 17
—signals and interlocking 465
—signs, fences and crossings 437
—ties 95
—track 155
—water service 625
—wooden bridges and trestles 281
—yards and terminals 681
Density, rule for Southern Yellow Pine and Douglas Fir 336
Design—
—cut track spike 199
—engine house 243
—flashing 791
—freight houses 247
—frogs 221
—manganese steel pointed switches 233
—reinforced concrete 420
—retaining walls 425
—screw spike 200
—steel railway bridges 743
—tie plates 203
—track fastenings 194
—yards 694
Drainage 57, 66, 791
Dragline excavators 35
Drilling of rails 124
Drinking water 659
Drop test machine, specifications for 125

E

Easement curve, minimum length of 159
Economy curves for structures of various ratios of life periods 301
Economics of Railway Location—
—comparison of alternate locations 803
—definitions 800
—distance and revenue 805
—engine districts 801
—lessening first cost 802
—locations governed by traffic 800
—momentum gradients 802
—passing sidings 801
—power 805
—ruling gradients 801
—train resistance 803
Electricity—
—definitions 853
—electric light, power supply and trolley lines crossing steam and electric railways, specifications for 861

Electricity—Continued. Page
—electrified railways, overhead clearance lines for permanent way structures on............ 854
—light wires and cables, specification 903
—trolley line crossings........... 873
—underbridge crossings 875
Elevation posts 463
—of curves 603
Employees, rules governing....... 571
—rest houses for................. 265
Engineering department forms.... 499
Engine house design.............. 243
Estimate, definition 17
—monthly report form............ 506
Excavators, dragline 35
Expansion, temperature, for laying rails 194
Expenditures, monthly report form 518

F

Fastenings, track, design of....... 194
Fences, definitions 437
—concrete 449
—right-of-way, specifications for.. 438
—snow 451
—table of material required for.... 443
Field parties, instructions to engineering 567
Fires, rules for the prevention of the spread of forest and field. 952
Fixtures, switch plans............ 213
Flangeway, width of standard.... 187
Flashing, principles of designs.... 781
Foaming and priming............ 657
Foot guards 216
Formation of the roadway, specifications 22
Forms—
—agreement for grade crossing.... 979
—agreement for interlocking plant 972
—bond 967
—bridge inspection 610
—construction contract 955
—engineering department 499
—industry track agreement........ 968
—inspection of timber treatment.. 850
—lease agreement for industrial site 986
—pile record 287
—proposal 954
—rail record 139
—records of cross-ties............ 106
—water service records........... 676
Foul ballast, cleaning............. 93
Foundations, pressure on......... 432
Freight houses—
—design of inbound and outbound 247

Freight houses—Continued. Page
—tracks, car capacity............ 688
—transfer stations 692
Frogs—
—definitions 155
—designs 221
—plans for 213
—specifications for 214
Formulas—
—ballast deck trestles, comparative economic value 296
—design of retaining walls....... 425
—determination of functions of the ten-chord spiral 162
—economic comparison of cross-ties of different materials..... 107
—elevation of curves............. 184
—impact for reinforced concrete structures 420
—impact for steel railway bridges. 746
—spacing of tank hoops.......... 663
—spirals 160
—testing quality of gravel for ballast 77
—train resistance 803

G

Gage on curves................... 188
—definition of 156
—maintenance of 186, 603
—testing, for screw spike......... 202
Gates for right-of-way fences..... 449
Grade crossing agreement form... 979
—reduction work 53
—separation 67
Grading, definition 19
—monthly estimate form.......... 503
—rules for lumber and timber..... 303
—specifications for 24
Gravel, definition 70
Grubbing, specifications for........ 24
Guard rails, specifications for..... 214
—use of 291

H

Haul 29
Heavy service scales, specifications for 696
Hemlock, specifications for........ 360
Highways, symbols 545
Houses—
—engine 243
—freight 247
—oil 257
—rest, for employees............. 265
—section tool 279
Hump yards 689
Hydrography, symbols 541

I PAGE

Indications conferring or restricting rights 472
Indicators, requisites of switch.... 476
Industrial site, form of lease agreement 986
Industry track agreement form... 968
Inspection—
—bridge erection 730
—bridge report form............... 510
—current bridge report form...... 512
—fabrication of steel bridges...... 727
—forms for reporting timber treatment 850
—of bridges and records of....... 725
—of structural steel................ 725
Instructions—
—for the care of water stations... 645
—for the guidance of engineering field parties 567
—for the inspection of bridge erection 730
—for the inspection of the fabrication of steel bridges......... 727
—for the mill inspection of structural steel..................... 725
—to govern ballasting on an operated line 83
Interlocking plants, division of expense 472
—form of agreement.............. 972
—signals and 465
Internal combustion engines, definition 626
—examination questions 650
Iodine potassium ferricyanide starch color reaction test..... 848
Iron and Steel Structures—
—classification of bridges for operating purposes 790
—column formula 732
—column tests 732
—contracting for steel railway bridges 737
—general specifications for steel railway bridges 742
—inspection of bridges and records of inspection............. 725
—instructions for the inspection of bridge erection 730
—instructions for the inspection of the fabrication of steel bridges 727
—instructions for the mill inspection of structural steel........ 725
—principles for detailed design of flashing, drainage, reinforcement and protection for waterproofing purposes 791

PAGE

Iron and Steel Structures—Continued.
—requirements for the protection of traffic at movable bridges.. 733
—rules and unit stresses for rating existing bridges.......... 787
—specifications for bronze bearing metals for turntables and movable bridges 735
—specifications for the erection of railway bridges 737

J

Joint bars, oil-quenched steel, specifications for heat-treated.... 137
Joint interlocking plants, division of expense 472

L

Lag screws, use of................ 291
Laying rails, temperature expansion 194
Lease record 528
—agreement form................. 986
Light service scales, specifications for 696
Lighting, yard 692
Limiting curve 159
Line, definition of................. 156
—maintenance of 157, 602
List of the Findings, Conclusions, Standards and Specifications contained in the Manual of the Signal Section, A. R. A....... 477
Locomotive coaling stations....... 256
—cranes 42
Lumber, classification of the uses of 364
--specifications, classification and grading rules................. 303

M

Main Line, definition.............. 156
—Track, definition 156
Maintenance—
—of gage 186
—of line 157
—of surface 184
—of way organization............ 608
Malleable iron tie-plates, specifications for 210
Manual block signals.............. 469
—for employees of the maintenance of way department..... 571
—instructions for guidance of engineering field parties......... 567
—location of 470
Maps, specifications for........... 530
Masonry, definitions 369
—specifications for 394

Page
Master scales, general specification for 721
Material report, monthly track.... 508
—classification 24
—monthly bridge 509
Materials, economic comparison of cross-ties of different.......... 107
Mechanical shovels 35
—tools 93
——use and limitations............ 93
Metal details, specifications....... 283
Metals, bronze bearing, for movable bridges and turntables... 735
Methods of depositing concrete under water 423
—of repairing defective surfaces of concrete 435
—of snow removal................. 457
—of testing quality of pit run gravel for ballast.............. 77
—of testing cement............... 377
—of tunnel construction in hard rock 59
—of tunnel construction in soft rock 61
Meters, water 639
Mile post 459
Mill inspection of structural steel. 725
Minor curves 159
Monolithic construction 433
Motor cars, rules governing use of 580
Movable bridges, requirements for the protection of traffic at.... 733

N

Nails, common 447
—dating, use of.................... 105
——specifications for.............. 105
Names for varieties of structural timber 303
Natural cement, specifications for. 392

O

Oak timbers—
—construction 351
—specifications for 352
Oil engines in water stations...... 646
—houses 257
—specifications for analysis....... 823
—tanks, specifications 667
Operation, yard 694
—water softeners 655
Organization, science of.......... 607
—of a ballast raising gang........ 87
—of the maintenance of way department 608
—water service 642
Overhaul, clause 29

Page
Overhead clearance lines on electrified railroads 854

P

Passenger stations 258
—terminal stations 692
Picks, tamping 92
Piers, definitions 683
—at rail and water terminals...... 686
Pile, definitions 282
—driving, principles of practice... 284
—record form 287
—sections 418
—timber, specifications for........ 283
—trestle, specifications for workmanship 288
Pipe lines, definition.............. 625
—lines, symbols 546
Plans for turnouts, frogs, switches and fixtures 213
Plows 48
—snow 452
Pockets, water, in roadbed........ 64
Portland cement, specifications for 375
Posts, concrete fence.............. 449
—right-of-way fence 440
Power, locomotive tractive........ 805
—cables, specifications for underground conduit construction... 932
Preservative treatments of wood, specifications for 835
—creosote oil (empty-cell process with final vacuum)........... 842
—creosote oil (empty-cell process with initial air and final vacuum) 843
—creosote oil (full-cell process)... 838
—zinc-chloride 836
—zinc chloride and creosote oil... 839
—zinc-tannin 837
Price and measurement of grading 29
Principles—
—of design of inbound and outbound freight houses.......... 247
—of design of flashing............ 791
—of design of retaining walls...... 432
—of design of tie-plates........... 203
—pile-driving 284
—water supply service............. 628
Priming and foaming.............. 657
Profiles, specifications for......... 530
—progress 539-540
Property line post................ 461
Proposal, form of.................. 954
Protection of traffic at movable bridges 733
—of records........................ 566

PAGE

Pumphouse, in water stations..... 645
Pumping plants, water, size....... 629
Pushcars, rules governing use of.. 580

Q

Quality of water, method of treatment 654
Questions for care of boilers in water stations 648
—for care of electrically operated pumps 653
—for care of internal combustion engines 650

R

Rail—
—broken 599
—drilling 124
—failures, classification of........ 147
—failures in main track, form for reporting 146
—failures for the year, form for reporting 150
—joints, general requirements.... 194
—joint, standard test for.......... 133
—location of borings for testing... 128
—record forms 139
—relayer, specifications for........ 194
—renewals of 597
—sections 115
—specifications for carbon steel.... 115
—temperature expansion for laying.194
Railway Signal Association, list of findings, standards, conclusions and specifications 477
Railways, classification of......... 16
Reagents used in water softening. 656
Records and Accounts............. 499
—engineering department forms.. 499
—of cross-ties.................... 106
—protection of.................... 566
—water service.................... 676
Reservoirs, impounding, for railway purposes.................. 634
Resistance, curve, freight cars.... 817
—train 814
Rest houses for employees........ 265
Retaining walls, design of........ 425
—masonry 396
Reinforced concrete structures, designs of 420
Requisites of switch indicators.... 476
—for switch stands................ 233
Right-of-way, definition........... 17
—care of 594
—fences 438
—gates 449
—maps 530

Right-of-way—Continued. PAGE
—signs or symbols................ 541
Road crossing signs............... 455
Roadway—
—allowance for shrinkage in embankments 52
—care of 596
—definitions 17
—drainage of large cuts.......... 68
—drainage through stations and yards 66
—general contract requirements.. 21
—grade reduction work............ 53
—grade separation 67
—information signs................ 455
—means for prevention of water pockets 64
—mechanical shovels 35
—shrinkage and subsidence........ 52
—slopes of roadway cross-section.. 22
—specifications for the formation of 22
—surface and sub-surface drainage 57
—tunnel construction 58
—tunnel ventilation 62
—washouts 57
—waterways 54
—width of, at sub-grade.......... 21
Roofings 273
Rules and Organization—
—and unit stresses for rating existing bridges 787
—density, for Southern yellow pine. 336
——for Douglas fir................ 337
—grading, for lumber and timber.. 303
——for cypress lumber and shingles 354
——for hemlock lumber........... 360
—inspection of bridges, trestles and culverts 610
—location, maintenance, operation and testing of track scales.... 716
—manual of instructions for the guidance of engineering field parties 567
—manual of rules for the guidance of employees of the Maintenance of Way Department... 571
—rules for inspection of bridges, trestles and culverts........... 610
—the science of organization...... 607

S

Safety rules 586
Sand, definition 375
Sanitary provisions for passenger stations 260
Scale, track, specifications for... 696

Scale—Continued. PAGE
—rules for location, testing, etc.. 716
—test cars 723
Screw spike, design of........... 200
—specifications for 198
—testing gage for................ 202
Section—
—ballast 80
—foremen, agencies for obtaining a better class 236
—post sign 460
—rail 109
—roadway 22
—rules governing foremen........ 584
—tool houses 279
—tunnel 58
Sidetrack record 508
Signals and Interlocking.......... 465
—definitions 465
—division of expense of joint interlocking plants............... 472
—findings, conclusions, standards and specifications, Signal Section, American Railway Association 477
—indications and aspects.......... 473
—manual block 469
—symbols 554
—train order 468
—use of 578
Shrinkage and subsidence........ 52
Signs, Fences and Crossings...... 437
—concrete fence posts............ 449
—definitions 437
—gates for right-of-way fences.... 449
—roadway information signs...... 455
—snow fences, snow sheds and methods of snow removal.... 451
—specifications for fences......... 438
—table of material required for fences 443
Slides 56
Slopes for high cuts.............. 67
—of roadway cross-section........ 22
Smoke jacks 245
Snow fences, snow sheds and methods of snow removal...... 451
—permanent snow fence.......... 453
—plows 452
Specifications—
—ballast tools 88
—billet-steel concrete reinforcement 412
—bronze bearing metals for turntables and movable railway bridges 735
—burnt clay ballast................ 78
—carbon steel rails................ 115
—concrete, plain and reinforced.. 400

Specifications—Continued. PAGE
—concrete piles, constructing premolded 415
—concrete piles, driving premolded 416
—construction oak timber......... 351
—creosote-coal-tar solution 821
—creosote oil analysis............ 823
—creosote oil, grades 1, 2 and 3.. 819
—cross-ties 97
—cut track spikes................. 197
—cypress lumber and shingles.... 354
—dating nails 105
—definition 17
—design and dimensions of manganese steel pointed switches. 233
—drop testing machine........... 125
—electric light, power supply and trolley lines crossing steam and electric railways.............. 861
—electric wires and cables....... 903
—erection of railway bridges...... 737
—fences, right-of-way............. 449
—formation of the roadway........ 22
—galvanizing or sherardizing...... 889
—high carbon steel joint bars.... 128
—joint bars, quenched carbon and quenched alloy 137
—lumber and timber.............. 303
—malleable iron tie plates........ 210
—maps, charts and profiles........ 530
—manganese steel pointed switches 233
—masonry 394
—master scales 721
—medium carbon steel track bolts with nuts 135
—metal details used in wooden bridges and trestles........... 293
—nails, dating 105
—natural cement.................. 392
—preservative treatments of wood. 835
—piles, concrete 416
—pit-run gravel ballast............ 77
—Portland cement 375
—quenched carbon and quenched alloy steel track bolts with nuts 130
—rails, carbon steel............... 115
—relayer rail for various uses.... 194
—right-of-way fences.............. 449
—sodding with Bermuda grass.... 62
—spikes, cut track................ 197
—stone ballast material............ 71
—steel railway bridges, general.. 742
—steel screw spikes............... 198
—steel tie plates.................. 203
—steel water and oil tanks........ 667

Specifications—Continued. Page
—stone masonry 394
—structural oak timbers........ 352
—switches, frogs, crossings and guard rails 214
—switch-ties 101
—tank hoops 663
—timber piles 283
—track scales 696
—underground conduit construction for power cables........ 932
—washed gravel ballast........ 75
—wood poles 887
—wooden bridges and trestles, metal details used in........ 293
—wooden water tank........ 666
—workmanship for pile and frame trestles 288
—wrought-iron tie plates........ 208
—zinc-chloride 835
Spirals 160
—formulas for field use........ 163
—staking spirals by deflection.... 164
—staking spirals by offsets........ 164
—table of functions of the ten-chord 165
Stations—
—freight transfer 692
—passenger 258
—terminal 692
—water 645
Steel joint bars, specifications for. 128
—cut track spikes, specifications for 197
—railway bridges, general specifications for 742
—screw track spikes, specifications for 198
—track bolts with nuts, specifications for 135
—track bolts, specifications for.... 130
—water and oil tanks, specifications for 667
Stone ballast, specifications for.... 71
—conduits 902
—masonry, definitions 371
——specifications for 394
Storehouse, reasons for maintaining 566
Sub-division and section post...... 460
Surface, definition of........ 156
—and sub-surface drainage........ 57
—maintenance of 184
—stock guards 450
Switch, definition of........ 157
—plans 213
—requisites of indicators........ 476
—specifications 214
—stand connecting rods........ 235

T Page
Tables—
—and curves of conductor sags.. 877
—average evaporation in locomotive boilers 807
—comparative sizes of wire gage. 445
—cylinder tractive power........ 811
—electric wires and cables........ 908
—functions of ten-chord spiral.... 166
—locomotive resistance 813
—material required for fences.... 443
—percentage of adjusted tonnage rating 816
—pole circumferences 888
—practical and theoretical turnout leads 237, 238
—pumping plant boilers........ 631
—quantity of reagents-water treatment 657
—sawed pole dimensions........ 888
—size of pumping plants........ 629
—tractive power 812
—weight of steam........ 808
—wood pole dimensions........ 887
—working stresses for structural timbers 302
Tamper, mechanical 93
Tamping bars, specifications for.. 90
—picks 92
—proper method of........ 185
Tangents 157
Tank hoops, specifications for.... 663
Team delivery yards........ 689
Temperature expansion for laying rails 194
Testing gage for screw spike...... 202
Test rail, statement of comparative wear 154
Ties, definitions 95
—dating nails, use of........ 105
—economic comparison 107
—plates, general principles of design 203
—plates, steel, specifications for.. 203
—records of 106
—renewals in continuous stretches versus single tie renewals.... 106
—specifications for cross-ties..... 97
—storage of 596
—switch, specifications for........ 101
Timber, specifications, classification and grading rules........ 303
—defects of manufacture........ 330
—names for varieties........ 303
—structures for water tanks...... 666
Timbers, grouping of, for antiseptic treatment........ 819
—determination of zinc in........ 848
—supply, conservation of........ 104

PAGE
Time roll 525
Tools, ballast 88
—houses, section 279
—mechanical, use and limitation of 93
—report form 509
—track, care and use of.......... 606
Topographical maps, symbols...... 542
Track—
—anti-creepers 212
—bolts, specifications for.......130, 135
—chart 539
—classification 16
—cut spike 197
—definitions of terms............. 155
—desirable agencies for obtaining better class of foremen........ 236
—elevation work 54
—fixtures, symbols 544
—flangeway, width 187
—frog designs 221
—gage on curves.................. 188
—line, maintenance of............ 157
—maintenance of gage............. 186
—maps 530
—material report 508
—plans for frogs, switches, crossings, guard rails and turnouts. 213
—posts and signs.................. 455
—relayer rail, specifications for.... 194
—requisites for switch stands.... 233
—screw spike 198
—specifications for frogs, switches, crossings and guard rails...... 214
—spikes, cut and screw........197, 198
—spirals 160
—standard rail joint............. 194
—steel tie plates, specifications for. 203
—switch leads, tables..........237, 238
—temperature, expansion for laying rail 194
—tie plates, general principles of design 203
—tools, care of.................. 606
—turnouts, plans of.............. 213
—yard, definitions 682
Train order signals.............. 468
—operation, signals for.......... 487
Trestles, rules for inspection...... 610
Trespass signs 455, 457
Tungsten lamp standards.......... 951
Tunnels 57
Turnouts, speed of trains through. 188
—leads, tables of practical and theoretical 237
—plans for 213
Turntables, specifications for bronze bearing metals......... 735

U PAGE
Underground conduit construction. 932
Uniform General Contract Forms. 954
—agreement for crossing of railways at grade................ 979
—agreement for interlocking plant 972
—construction contract........... 955
—form of bond.................... 967
—industry track agreement....... 968
—lease agreement for industrial site 986
Unit stresses for structural timbers 302
—for rating existing bridges..... 787
—structural steel 747

V
Valuation section sign............ 464
Velocipede cars, use of........... 580
Vicat apparatus 384

W
Walls, retaining, design of........ 425
Washouts 57
Water Service—
—definitions 625
—drinking 659
—foaming and priming............ 657
—general principles of supply...... 628
—impounding reservoirs for railway purposes 634
—instructions for care of water stations 645
—meters for use in railway service 639
—minimum quantity of scaling and corrosive matter which will justify treatment 658
—quality of water—method of treatment 654
—records 676
—softeners 655
—steel substructures for tanks.... 666
—steel water and oil tanks, specifications for 667
—tank hoops, specifications for... 663
—timber, substructures for tanks. 666
—wooden water tank, specifications for 660
Water pockets in roadbed......... 64
Waterproofing of masonry........ 433
Waterways 54
Wells, record of deep............ 680
Wires and cables, specifications for 903
Wood Preservation—
—antiseptic treatment, grouping of timbers for 819

Wood Preservation—Continued. Page
—coal-tar in creosote, use of...... 822
—creosote-coal-tar solution, specifications for 821
—creosote oil analysis, specifications for 823
—creosote oil, specifications for... 819
—iodine potassium ferricyanide starch color reaction tests for determining zinc chloride penetration 848
—inspection of timber treatment, forms for reporting............ 850
—method for determining strength of zinc-chloride solution....... 846
—methods for determining absorption of creosote oil and creosote-coal-tar solution 844
—poles, specifications for.......... 887
—preservative treatments, specifications for 835
—water in creosote................ 844
—zinc in treated timbers, determination of 848
Wooden Bridges and Trestles—
—classification and grading rules for lumber and timber........ 303
——cypress lumber and shingles.. 354
——hemlock lumber 360
——of terms 304
——uses of lumber................ 364
—comparative merits of ballast deck and reinforced concrete trestles 295
—definitions of blemishes and defects 306
—Douglas fir, specifications for.... 336
—economy curves for structures of various ratios of life periods.. 301
—grading lumber and timber, general instructions 341
—lag screws, use of, in trestle construction 291
—metal details, specifications for.. 293
—names for varieties of structural timber 303
—pile-driving, principles of practice 284
—pile record form................. 287
Wooden Bridges and Trestles—Continued. Page
—relative economy of repairs and renewals 295
—Southern yellow pine, specifications for 336
—standard sizes 330
—structural grades for bridge and trestle timber 336
——oak timbers, specifications for. 352
—trestles, pile and frame, specifications for workmanship..... 288
—working stresses for structural timbers 302
Workmanship—
—frogs, crossings and switches.... 218
—pile and frame trestles.......... 288
—screw spikes 201
—steel railway bridges............ 770
—tie plates 207
—track spikes 197
—water tanks 666, 667
Wrought-iron tie plates........... 208

Y

Yards and Terminals—
—car capacity of freight tracks.. 688
—definitions of terms............. 681
—freight transfer stations......... 692
—general requirements 683
—hump yards 689
—lighting 692
—passenger terminal stations..... 692
—situation plans for division engine terminal 693
—team delivery yards............. 689
—track scales, specifications for.. 696
——rules for the location, maintenance, operation and testing. 716
—transfer of lading of bad-order cars 693
—yard design and operation...... 694

Z

Zinc-chloride, specification for.... 835
—chloride solution, method of determining the strength of...... 846
—in treated timbers, determination of 848
—tannin, specifications for........ 837

2774 66

NORTHEASTERN UNIVERSITY LIBRARIES
3 9358 00865236 1

DUE DATE

AUG 1 9 2003			
			Printed in USA

NORTHEASTERN UNIVERSITY LIBRARIES
3 9358 00865236 1